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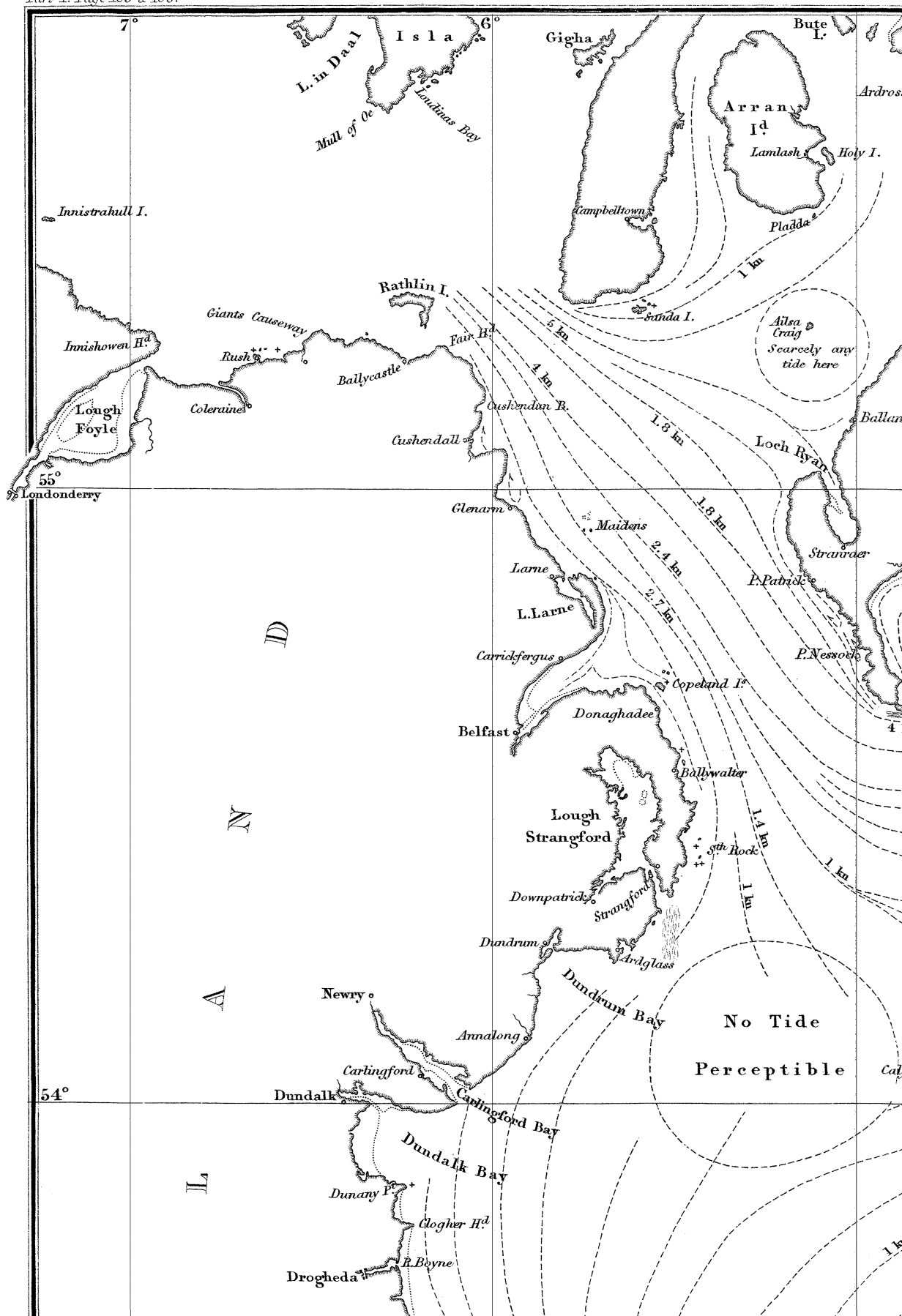
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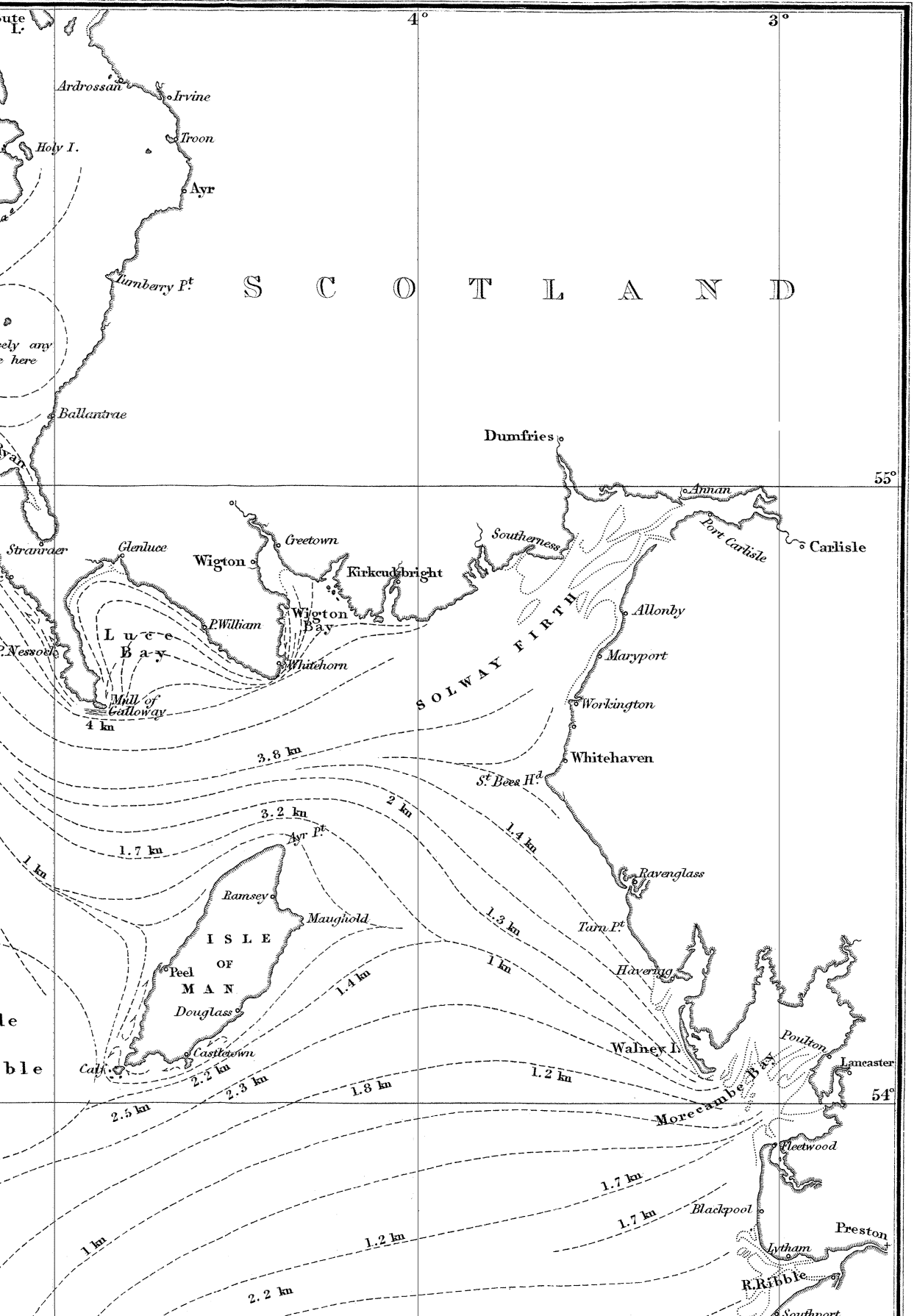
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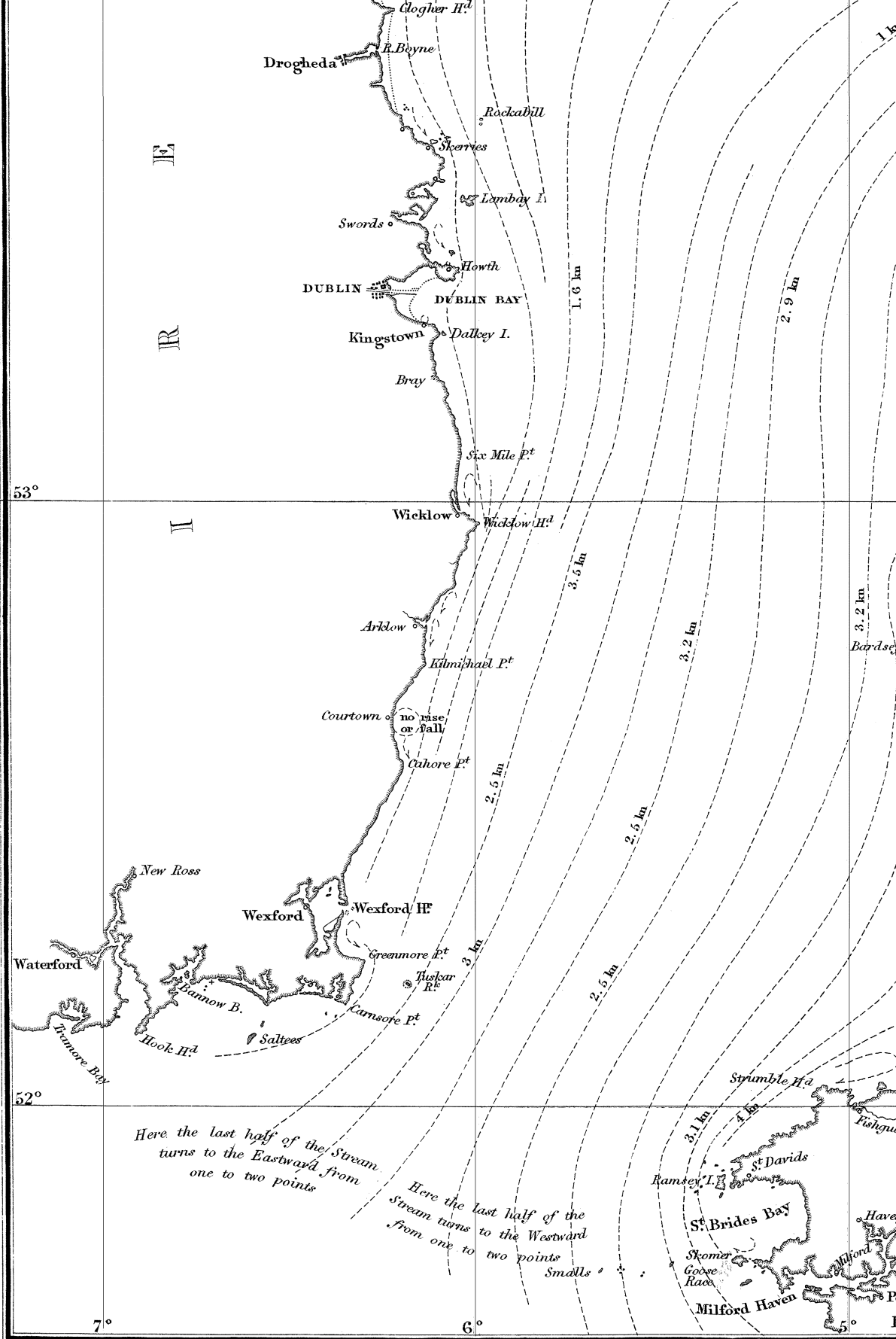
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VI. *Report of Observations made upon the Tides in the Irish Sea, and upon the great similarity of Tidal Phenomena of the Irish and English Channels, and the importance of extending the Experiments round the Land's End and up the English Channel. Embodied in a letter to the Hydrographer. By Captain F. W. BEECHEY, R.N., F.R.S. Communicated by G. B. AIRY, Esq., F.R.S. &c., Astronomer Royal.*

Received March 22,—Read March 29, 1848.

SIR,

London, February 19th, 1848.

IT is with much pleasure I lay before you the result of observations which have been made upon the tides in the Irish Sea, during the execution of the survey which has been entrusted to my charge.

Up to the period of these observations the set of the tides in the Irish Sea had been greatly misunderstood, owing to the association of the turn of the stream with the rise and fall of the water on the shore; and it was generally understood that as Holyhead was three hours later in its tides than places at the entrance of the channel, a vessel starting with the first of the flood would carry nine hours' tide in her favour in her run up channel and *vice versa*. The stream in the Irish Channel hitherto misunderstood.

This was an error sufficiently great in itself, but it was liable to be increased by an entire ignorance as to the time when a vessel would take any particular tide; for the times of high water by the shore were very various on different sides of the channel.

The present inquiry, I am happy to inform you, has set these errors and doubts at rest. The observations have shown that, notwithstanding the variety of times of high water throughout the channel, the turn of the stream is *simultaneous*; that the northern and southern streams in both channels commence and end in all parts (practically speaking) *at the same time*, and that time happens to correspond with the time of *high and low water* on the shore at *Morecombe Bay*; an estuary rendered remarkable as being the point where the opposite tides coming round the extremities of Ireland, finally meet. So that it is necessary only to know the times of high and low water at Morecombe Bay to determine the hour when the stream of either tide will commence or terminate; a fact which will, I am sure, be fully appreciated by every person navigating the Irish Channel at night, or in thick weather. Turn of the stream simultaneous throughout north and south channels. Meeting of tides.

The chart of curves or lines of *direction of the stream*, Plate II., which accompanies this report, will show at once the effect of the tide upon a vessel wherever she may be placed in the channel, and especially direct her where, with a beating wind,

she will be benefited by standing in shore or otherwise; and will warn her of the danger of drawing near the shores of Cardigan or Caernarvon Bays, with particular tides and scant winds, and so likewise of the danger of standing close to the banks skirting the Irish coast in light winds.

Peculiar
feature of the
tides.

But it is not to the navigator alone that these observations will, I hope, be found useful: they will, I think, be interesting to men of science. Taken in connection with the very valuable series of observations which were carried round Ireland by the Ordnance at the suggestion of Professor AIRY, we are made acquainted with several curious facts: first, that whilst it is high water at one end of the channel, it is low water at the other; that the same stream makes both high and low water at the same time; that there are two spots in the channel, in one of which the stream runs with considerable velocity without the water either rising or falling, and in the other, that the water rises and falls from sixteen to twenty feet without having any visible horizontal motion of its surface; and that during the first half of the flowing, and last half of the ebbing, tide-wave, the stream in the south channel runs in a contrary direction to the wave, and goes up an ascent of about one foot in $4\frac{1}{2}$ miles. (See Plate IV.)

To the lines of direction of the stream I have added the rate of the tide at its greatest velocity on the day of syzygy, and have reduced all to the same standard.

I shall now proceed to describe the general course of the streams throughout the channel; point out the situations in which the meeting of the tides occurs; and offer such remarks on the course of the stream and upon the tidal phenomena of this sea, as will, I conceive, benefit the navigator, and be interesting to science.

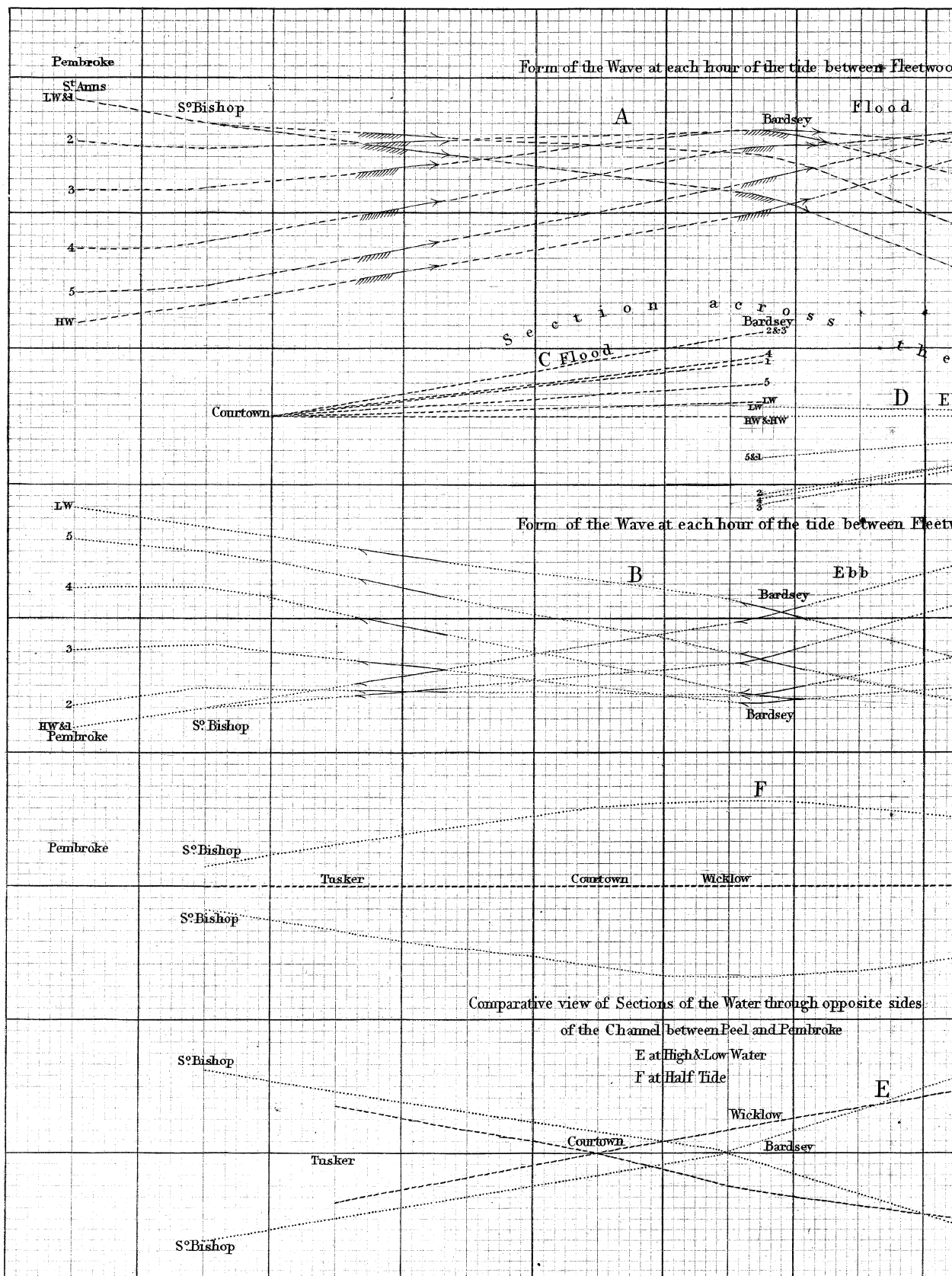
An inspection of the chart (Plate II.) will show that the tide enters the Irish Sea by two channels; of which Carnsore Point and Pembroke are the limits of the southern one, and Rathlin and the Mull of Kintire the boundaries of the northern.

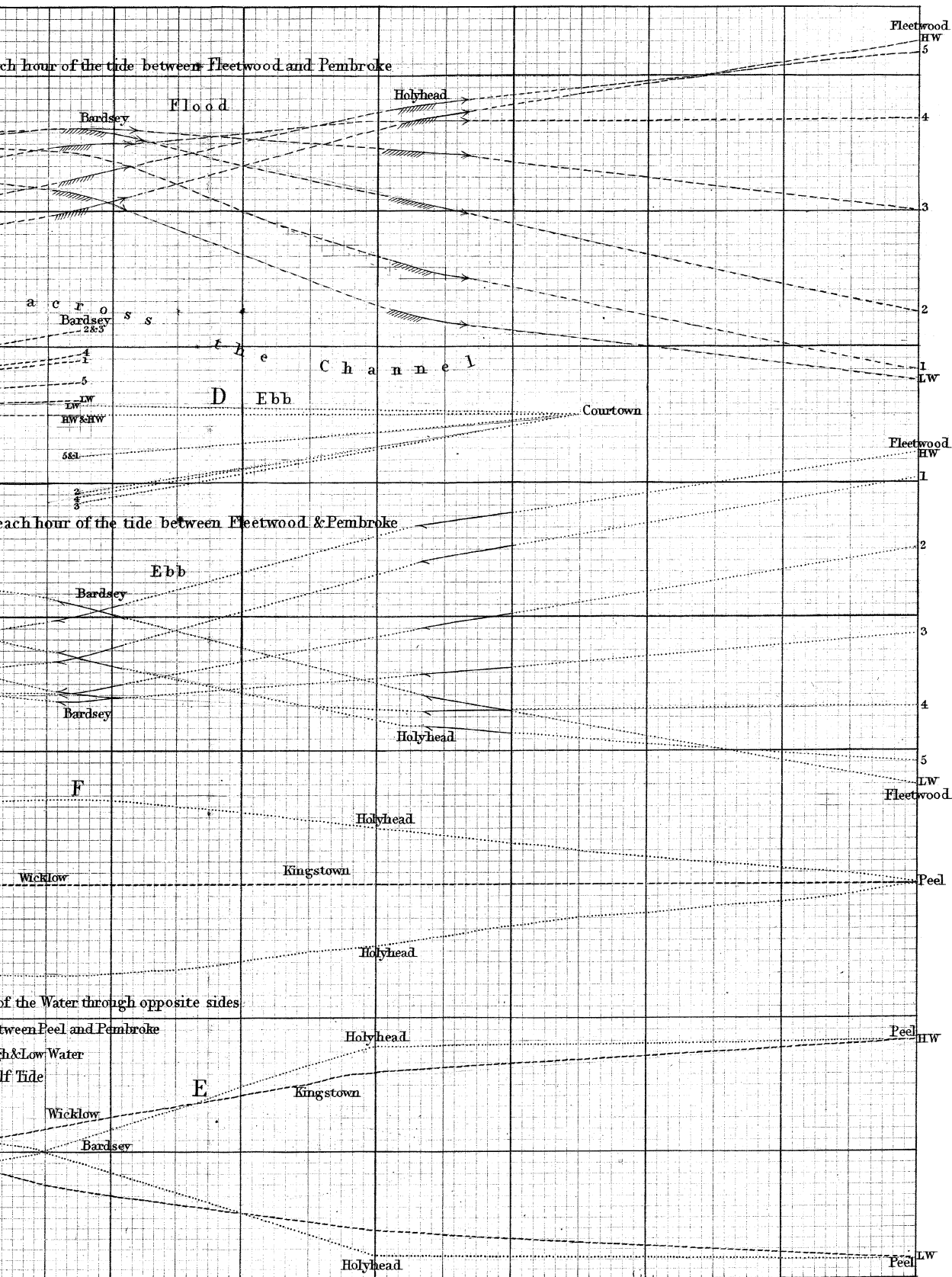
Times of
slack water
throughout
the channel.

The stream in the southern channel (as before stated) has been ascertained to move *simultaneously in one vast current throughout*; running six hours nearly each way, at an average rate of from two to three knots per hour at the height of the springs, increasing to four knots and upwards near the banks and at the pitch of the headlands; its *times of slack water* corresponding sufficiently near for all practical purposes, with *the times of high and low water for the day at Morecombe Bay*, or more correctly *at Fleetwood*, which is twelve minutes earlier than Liverpool.

Course of the
central por-
tion of the
stream in the
south
channel.

The *central portion* of the stream of *flood* or *ingoing stream*, runs nearly in a line from a point midway between the Tuskar and the Bishops, to one six miles due west of Holyhead; beyond which it begins to expand eastward and westward, but its main body preserves its direction straight forward for the Calf of Man, which it passes to the eastward with increased velocity as far as Langness Point, and then at a more moderate rate on towards Maughold Head. Here it is arrested by the flood or southern stream from the north channel coming round the Point of Ayre, and





is first swayed round to the eastward by it, and then goes on with it at an easy rate direct for Morecombe Bay.

The *outer portions* of the stream are necessarily deflected from the course of the great body of the water by the impediments of banks on the Irish side of the Channel, and by the tortuous form of the coast on the Welsh. The eastern portion passing Linney Head rushes with great rapidity between the Smalls, Grassholm, and Milford Haven, towards the Bishops, which it passes at a rate of between four and five knots; sets sharply round those rocks in an E.N.E. direction, right over the Bass bank, and into Cardigan Bay; makes the circuit of that bay; and sets out again towards Bardsey at the other extremity of it; then sweeping to the N. by W. past the island and through the sound, it gradually takes the course of the shore, round Caernarvon Bay, filling the Menai Strait as far as Bangor; but the stream still continuing outside towards the South Stack, which it rounds, setting towards the Skerries at a rate of upwards of four knots; and finally, turns sharply round those rocks for Liverpool and Morecombe Bay; completing in its way the high water in the Menai, and filling the Dee, Mersey and Ribble.

Course of the eastern portion of the stream in the south channel.

The *western* portion of the stream, after passing the Saltee, runs nearly in the direction of the Tuskar, sets sharply round it, and then takes a N.E. $\frac{1}{2}$ N. direction, setting fair along the coast, but over the banks skirting the shore, so that vessels tacking near the edge of the sands, have been carried upon them and lost, especially upon the Arklow and Codlin. Abreast of the Arklow is situated that remarkable spot in the Irish Channel, which I have before mentioned as a place where *the tide neither rises nor falls*. The stream notwithstanding sweeps past it at the rate of four knots at the springs, and reaches the parallel of Wicklow Head. Here it encounters an extensive bank recently known; and whilst the outer portion takes the circuit of the bank, the inner sweeps over it, occasioning an overfall and strong rippling all round the edge, by which the bank may generally be discovered; beyond this point the streams unite and flow on towards Howth and Lambay, growing gradually weaker as they proceed, until they ultimately expend themselves in a large space of still water situated between the Isle of Man and Carlingford.

Course of the western portion of the stream in the south channel.

Place of no rise or node of the tide-wave.

Here we have not been able to detect any tide; and here occurs that remarkable phenomenon before mentioned, of the water rising and falling without having any perceptible stream. This space of still water is marked by a bottom of blue mud. Such is the course of the flowing water in the *southern channel*.

Place of no stream.

In the north channel the stream enters between the Mull of Kintire and Rathlin *simultaneously* with that passing the Tuskar into the southern channel, but flows in the contrary direction. It runs at the rate of three knots at the springs, increasing to five knots near the Mull, and to four near Torr Head on the opposite side of the channel. The eastern branch of this stream turns round the Mull towards Ailsa and the Clyde, a portion passing round Sanda up Kilbrannin Sound and Loch Fyne.

Stream in the northern channel.

The *main body* sweeps to S. by E., taking nearly the general direction of the

Course of the main body of the stream.

Remarkable
ditch.

Eastern por-
tion of the
stream.

Central por-
tion of the
stream.

Western
portion of
the stream.

channel, but pressing more heavily on the Wigtownshire coast; off which it has scooped out a remarkable ditch, upwards of twenty miles long by about a mile only in width, in which the depth is from 400 to 600 feet greater than that of the general level of the bottom about it. Near the Mull of Galloway the stream increases in velocity to five knots, the eastern portion turns sharply round the promontory towards the Solway, and splits off St. Bee's Head; one portion running up the Solway, and the other towards Morecombe Bay.

The *central portion* from a midway between the Mull of Galloway and the Copeland Islands, presses on towards the northern half of the Isle of Man, and while one portion of it flows toward the Point of Ayre, the other makes for Contrary Head, and is there turned back at a right angle nearly to its early course. Passing Jurby it reunites with the other portion of the stream, and they jointly rush with a rapidity of from four to five knots round the Point of Ayre, and directly across all the banks lying off there, and catching up the stream from the south channel off Maughold Head, they hurry on together towards that great point of union Morecombe Bay. This bay, the grand receptacle of the streams from both channels, is notorious for its huge banks of sand heaped up in terrible array against the mariner unacquainted with its locality, and also remarkable for a deep channel scoured out by the stream, and known as the Lune Deep, which to the wary navigator is the great hidden beacon of his safety, and serves him, alike in fog or in sunshine, as a guide to his position, and to a harbour of safety in case of need.

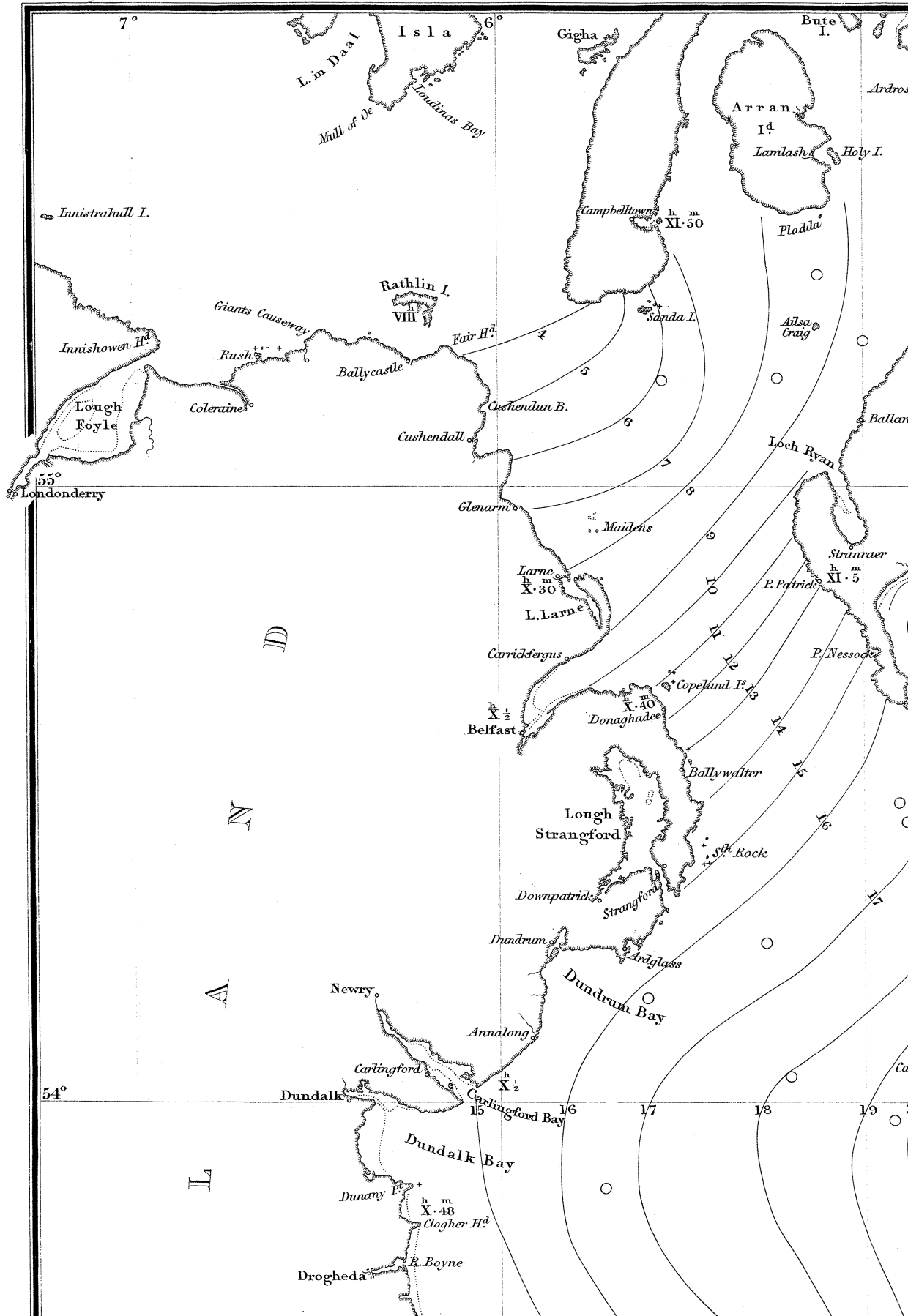
We have now only to speak of the *western limit* of the stream, which we left off Torr Head running at a rate of four knots off the pitch of the point. Hence it strikes directly towards the Maidens, boiling over the Highlander and Russell rocks, and other reefs in the vicinity of that dangerous group; and takes the direction of the coast again from Muck Island to Black Head, at the entrance of the Lough of Belfast, which it fills.

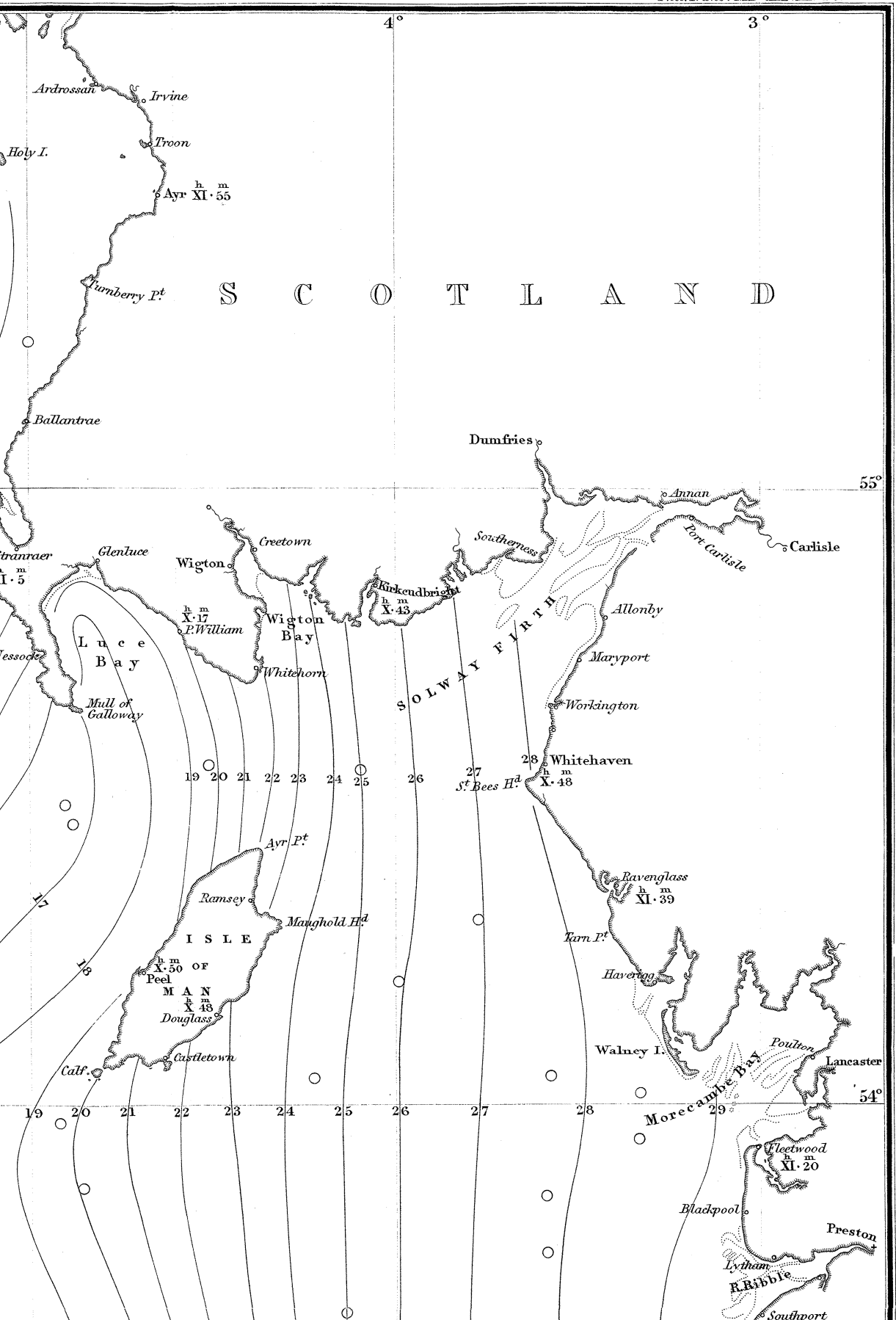
The portion of the stream which sets up the Lough, splits again off Grey Point; one portion flowing up towards Garmoye, while the other bends back along the shore of Bangor, Grimsport and Orlock, and blends with the general stream which has come on from the Maidens and Blackhead, and passes with it through the sounds of the Copeland Islands. Hence it proceeds along the coast, brushes the South rock, and runs on towards St. John's Point; off which, the stream, like that coming from the southward, expends itself in a large space of still water, which remains undisturbed although pressed upon by streams from various quarters.

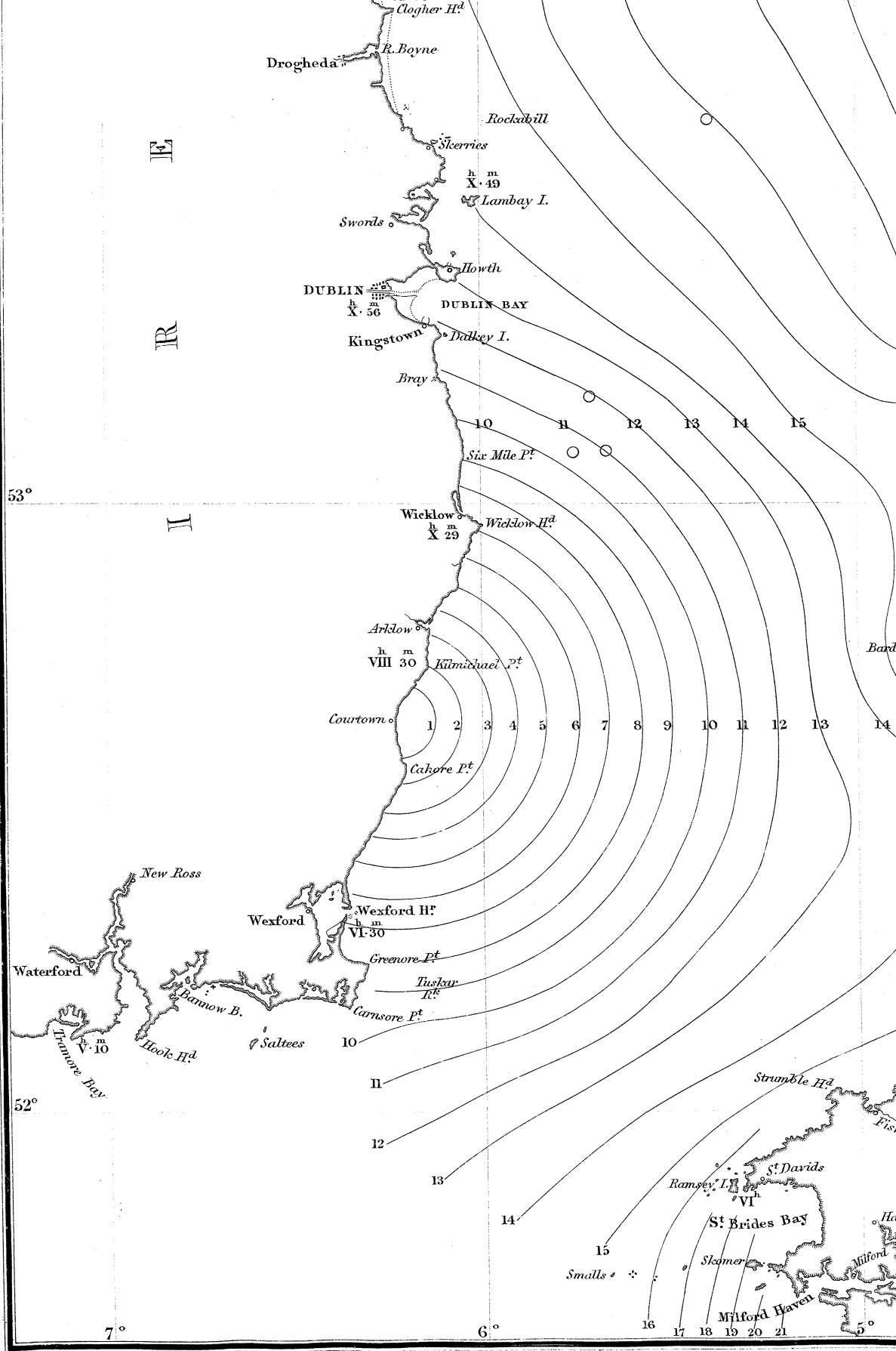
Such is a general description of the streams in both channels which attend the *flowing of the water*, or which, for the purpose of distinction, we may designate the *Ingoing stream*.

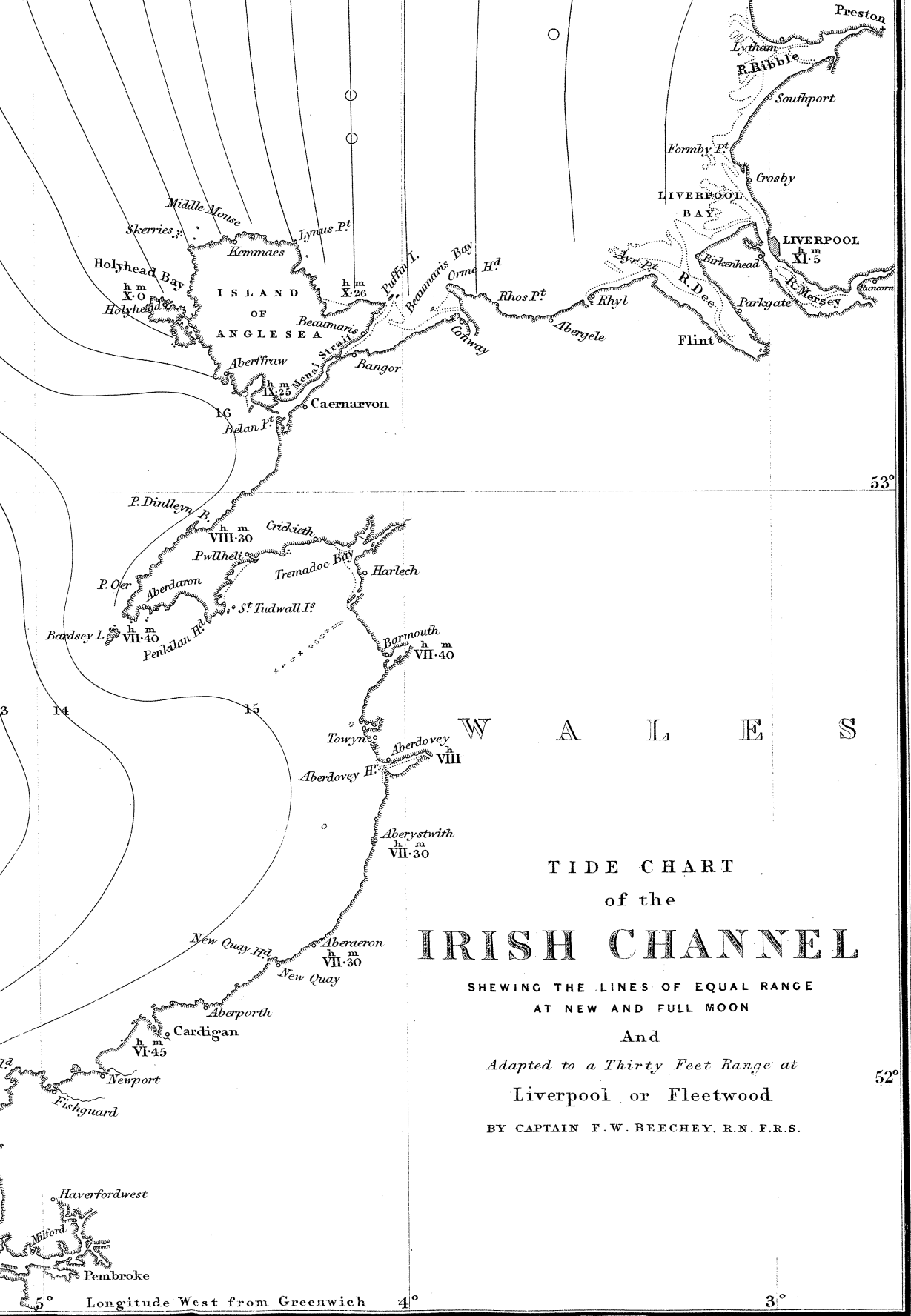
Ebbing or
outgoing
stream.

The ebbing or *Outgoing* streams do not materially differ from the reverse of these, except that in the southern channel they press rather more over towards the Irish coast.









These observations do not, however, extend beyond the point where the channels begin to open out, that is beyond a line joining Rathlin and the Mull of Kintire on the north, and the Saltee and Pembroke on the south. Outside these limits, the waters diverge right and left; that on the north joining the stream from Jura, and turning sharp round Rathlin; that on the south, speaking now of the outgoing stream, sweeps past Pembroke into the Bristol Channel on one side, and on the other rounds the Tuskar and passes on to Waterford.

I have now, Sir, endeavoured to convey to you a general idea of the course of the streams throughout the Irish Sea both in the centre and at the sides of the channel, as you will find them represented in the annexed chart, Plate II.; but besides these there are (as usual) at all the points and headlands, when abrupt, counter streams or eddies beginning at about two hours after the offing stream, increasing with the strength of the tide, and occasioning races and overfalls at the places marked on the chart. In the direction of the offing stream there is as little variation of the current at the different hours of tide as will be met with in any sea of similar extent, and indeed it is only with the slackening of the tide that the variations occur; so that, by a due attention to the lines I have given, the navigation may be as certainly conducted here as in any channel with which we are acquainted*.

During the time these observations on the stream were in progress, others were made upon the *rise and fall of the water* at several stations in the channel, and wherever practicable at places in the offing. By combining these observations with the range of tide on the coast of Ireland, published in Professor WHEWELL's admirable paper on the Tides in the Philosophical Transactions for 1836, Part II., and with observations made by Captains ROBINSON, DENHAM, FRAZER, SHERRINGHAM, WILLIAMS, &c., I have constructed a chart of lines of equal range of tide, Plate III., in order that the seaman may ascertain by a simple inspection of the chart, wherever he may be placed in the channel, the amount of spring range to which he has to adapt his soundings.

Chart of lines
of equal
range of tide.

In this chart the lines denote the range of tide at the places over which they pass, on a day when a spring tide at Liverpool rises thirty feet. In the channel between Holyhead and Tuskar, where it was impossible to get observations of this kind in the offing, the lines have been proportioned according to the known difference of range between the places.

In the sea to the northward of Holyhead the numbers have been compiled from observations made on calm days, at anchor, in connection with those made upon the shore around the places of observation.

The method of obtaining the range at sea was to moor a heavy weight with a small well-stretched line attached to it marked to feet, and to preserve as nearly as possible the same tension of line at the times when the depths were required, a loop was

Method of
obtaining
the range at
sea.

* It is slack water from about forty minutes before to about forty minutes after high or low water at Morecombe Bay.

placed over the hook of a small hand steelyard, and the line brought tight until the index noted a given quantity, which was afterwards considered the standard; and by comparing the observations of several days obtained in this manner with the tide gauges on shore, a near agreement satisfied me that the results were to be depended upon. At the same time it is not pretended that the rise has been determined to any great accuracy, although I think it is within the foot, and quite near enough for the purposes of navigation for which the chart is intended.

Table for the
reduction of
soundings.

To make this chart useful for the reduction of soundings at intermediate times between high and low water, I have annexed a diagram, Plate VII., constructed from a vast number of observations, and have given directions for using it.

Unequal motion of the upper and lower half of the tide-wave, common to all the tides in Irish Sea and Bristol Channel.

I shall now notice some peculiarities in the tides which have fallen under our observation. In the construction of the Table, Plate VII., for the use of the seaman, in the Irish Sea it was found that the place of the *water at the half-tide interval* did not correspond with that of a mark at *the half range of the wave*, but that it was always below it, showing that the upper half of the wave rose and fell more rapidly than the lower. It was also found that the curve of the Irish Sea tide did not correspond with that of the Bristol Channel tide; that neither followed the law of the sines to corresponding arcs of tidal intervals, upon the falling water especially, as may be seen in Plate VIII., constructed for the purpose of showing the place of the water at corresponding intervals of a falling tide at places distantly situated.

It was also seen that, owing to the unsymmetrical form of the curves, it would be necessary to have tables for the reduction of soundings adapted to rising and falling tides respectively. In Plate VI. I have exhibited the discordance of the curves of the rising and falling wave in the Bristol Channel, where it will be seen that at one stage of the tide, the difference of similar tidal intervals amounts to about four feet.

I may here mention that the Cumberland Basin Gauge (Mr. BUNT's), which has been frequently referred to in the Philosophical Transactions, corresponds very nearly with the Portishead Gauge with which the observations in Plate VI. were made.

Apparent mean elevation of the water.

In connection with the range of tide is that of the apparent mean elevation of the water. All the observations confirm the remark of Professor AIRY*, viz. that this mean level is higher at the springs than at the neaps. The mean place of the water however for an entire lunation, during the summer months at least, is tolerably constant, and affords a fair standard to which the reductions used in our nautical surveys may be referred in the event of the gauge being removed by which the observations were made.

As an example, I annex the result of observations made at Holyhead during nearly four entire years.

* Philosophical Transactions, 1845, Part I. p. 31.

Showing the Height of the Water at each tenth part of the interval of tide at
PORTISHEAD.

----- Rising tides
----- Falling tides
----- Mean
1848.

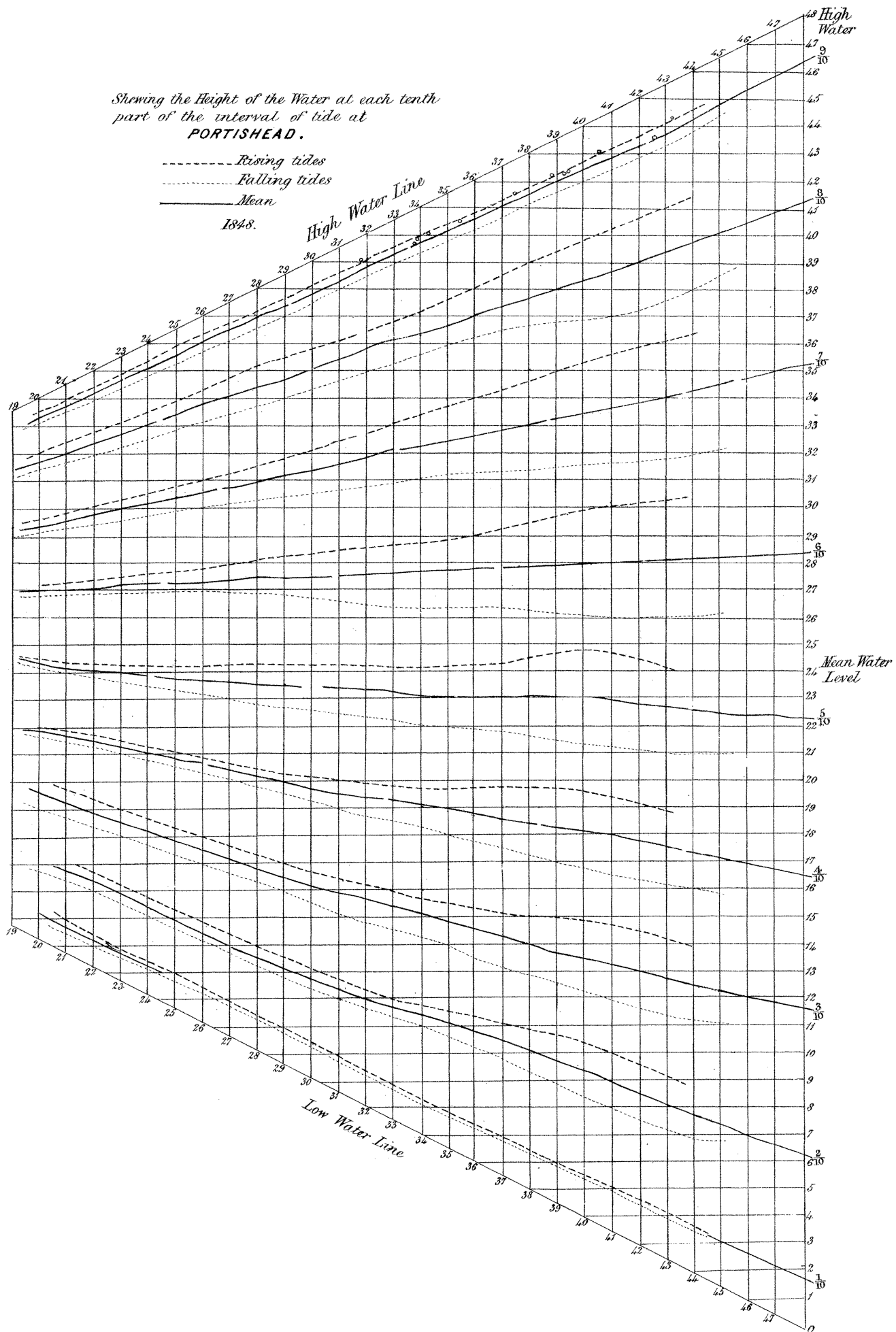


Table A.

| Names of Places. | Range at springs feet. | Names of Places. | Range at springs feet. |
|------------------|---------------------------|-------------------------------|---------------------------|
| Liverpool | 30 | Kellmore | 11 |
| Holyhead | 20 | Loughbar | 8 |
| Fleetwood | 28 | Dunmore | 15 |
| Pembroke | 22 | Rapsey I.M. | 22 |
| Kingstown | 15 | King Will. ^m Shank | 23½ |
| Belfast | 11½ | Ravenglass | 25 |
| Brcy | 10 | Whitchaven | 25 |
| Wicklow | 8 | Donaghadee | 15½ |
| Arklow | 3 | Bardsey Id. | 16 |
| Cahore | 3 | Nesker | 9 |
| Blackwater | 6 | Calf | 15½ |
| Wexford | 5½ | Peel I.M. | 16 |
| Carnore | 8 | | |

For other Places in the Irish Sea see the Tidal Chart Curves.

For other Places in the Irish Sea, see the Tidal Chart Curves.

To reduce Soundings roughly to low water springs.

Find the range for the day in the "tide tables."* From the time of high water at your station take the time of your

resounding and seek a corresponding time in table B. Trace this down under the range for the day above mentioned and parallel with it under the range at springs for the place (table C.) stands the quantity

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Sept. 20th 1840 Off Liverpool. Require the quantity to be taken
 P. M. High Water 1.48 P.M.

Range for the 20th Sept 2 1/4 ft

difference ? 12 Rising tide

in table B. under 2.4 feet range and 2.12^{in.} and parallel with it under the spring range 30 ft. stands 19.8^{in.} the quantity required.

to reduce the Soundings accurately. (1.) Take from the "Tide Tables" on the given day the high water preceding and following the

one of your sounding and subtract them, half this difference call the Duration of Tide. (2) Subtract your time from the nearest of

these times of high water. (3) Find from the tide tables the "Range for the day" (4). In table A, seek a duration of tide equal to yours. 30

over found, and opposite it the time of your sounding from high water, note the proportional part that are read of the column. (6.) ARRANGE THESE DATA AS FOLOWS.—First, the nearest dotted line to the intersection with the line that this water column went in the right hand column and proceed as directed below to trace the nearest dotted line to the intersection with the line

range for the day and parallel with it under the spring range stands the quantity required.

EXAMPLE. Sept. 20th 1845. off Liverpool, Required the quantity to be taken from a sounding at 4 P.M.

table A, opposite 6-19. ^{h. m.} 2-12 hulls about half way between $\frac{4}{12}$ and $\frac{6}{12}$ at the head of the column. In table B, under $2\frac{1}{4}$ feet range of tide and half way between $\frac{4}{12}$ and $\frac{6}{12}$ and parallel with it under

the spring range (from table C.) 30 feet stands 18th the quantity to be taken from the sounding.

Knowing the range for the day at Liverpool, the range for the day at any other place in the Irish Sea may be obtained approximately by the following rule.

EXAMPLE Required the range for the day at Bardson on the 8th September 1847 as 30 : 9 :: 22 : 30 feet, is to the range marked upon the tide chart, so is the range for the day as

$$30 / \frac{198}{6.770}$$

Table A.

| Duration of the trial Phase | $\frac{1}{12}$ | | $\frac{2}{12}$ | | $\frac{3}{12}$ | | $\frac{4}{12}$ | | $\frac{5}{12}$ | | $\frac{6}{12}$ | | $\frac{7}{12}$ | | $\frac{8}{12}$ | | $\frac{9}{12}$ | | $\frac{10}{12}$ | | $\frac{11}{12}$ | | $\frac{12}{12}$ | | | | |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|----------------|----------------|------|
| | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{1}{12}$ | $\frac{2}{12}$ | |
| 5:20 | 2.6 | 5.8 | 1.20 | 1.47 | 2.15 | 2.40 | 3.13 | 3.38 | 4.10 | 4.27 | 4.55 | 5.2 | 5.45 | 5.12 | 5.8 | 6.0 | 6.2 | 6.45 | 6.7 | 6.95 | 7.2 | 7.45 | 7.7 | 7.95 | 8.2 | 8.45 | 8.7 |
| 5:30 | 2.7 | 5.5 | 1.22 | 1.60 | 2.37 | 2.45 | 3.15 | 3.40 | 4.1 | 4.35 | 4.6 | 5.2 | 5.45 | 5.12 | 5.8 | 6.0 | 6.2 | 6.45 | 6.7 | 6.95 | 7.2 | 7.45 | 7.7 | 7.95 | 8.2 | 8.45 | 8.7 |
| 5:40 | 2.8 | 5.6 | 1.25 | 1.55 | 2.32 | 2.50 | 3.18 | 3.47 | 4.15 | 4.35 | 4.6 | 5.12 | 5.45 | 5.12 | 5.8 | 6.0 | 6.2 | 6.45 | 6.7 | 6.95 | 7.2 | 7.45 | 7.7 | 7.95 | 8.2 | 8.45 | 8.7 |
| 5:50 | 2.9 | 5.8 | 1.27 | 1.57 | 2.26 | 2.58 | 3.24 | 3.55 | 4.22 | 4.41 | 4.61 | 5.21 | 5.45 | 5.12 | 5.8 | 6.0 | 6.2 | 6.45 | 6.7 | 6.95 | 7.2 | 7.45 | 7.7 | 7.95 | 8.2 | 8.45 | 8.7 |
| 6:00 | 3.0 | 5.1 | 1.0 | 1.50 | 2.0 | 2.50 | 3.0 | 3.50 | 4.0 | 4.50 | 5.0 | 5.50 | 6.0 | 6.50 | 7.0 | 7.50 | 8.0 | 8.50 | 9.0 | 9.50 | 10.0 | 10.50 | 11.0 | 11.50 | 12.0 | 12.50 | 13.0 |
| 6:10 | 3.1 | 1.1 | 1.52 | 2.3 | 2.54 | 3.5 | 3.56 | 4.7 | 4.57 | 5.8 | 6.39 | 6.9 | 7.4 | 7.9 | 8.4 | 8.9 | 9.4 | 9.9 | 10.4 | 10.9 | 11.4 | 11.9 | 12.4 | 12.9 | 13.4 | 13.9 | 14.4 |
| 6:20 | 3.2 | 1.3 | 1.55 | 2.7 | 2.58 | 3.10 | 3.41 | 4.15 | 4.45 | 5.17 | 5.48 | 6.19 | 6.5 | 7.1 | 7.6 | 8.1 | 8.6 | 9.1 | 9.6 | 10.1 | 10.6 | 11.1 | 11.6 | 12.1 | 12.6 | 13.1 | 13.6 |
| 6:30 | 3.2 | 1.5 | 1.57 | 2.10 | 2.42 | 3.16 | 3.47 | 4.20 | 4.52 | 5.25 | 5.57 | 6.29 | 6.6 | 7.3 | 7.8 | 8.3 | 8.8 | 9.3 | 9.8 | 10.3 | 10.8 | 11.3 | 11.8 | 12.3 | 12.8 | 13.3 | 13.8 |
| 6:40 | 3.3 | 1.6 | 1.40 | 2.35 | 2.47 | 3.20 | 3.55 | 4.28 | 5.0 | 5.55 | 6.7 | 7.1 | 7.6 | 8.1 | 8.6 | 9.1 | 9.6 | 10.1 | 10.6 | 11.1 | 11.6 | 12.1 | 12.6 | 13.1 | 13.6 | 14.1 | 14.6 |
| 6:50 | 3.4 | 1.8 | 1.42 | 2.17 | 2.51 | 3.25 | 3.69 | 4.26 | 5.0 | 5.52 | 6.16 | 6.7 | 7.2 | 7.7 | 8.2 | 8.7 | 9.2 | 9.7 | 10.2 | 10.7 | 11.2 | 11.7 | 12.2 | 12.7 | 13.2 | 13.7 | 14.2 |

Table B.

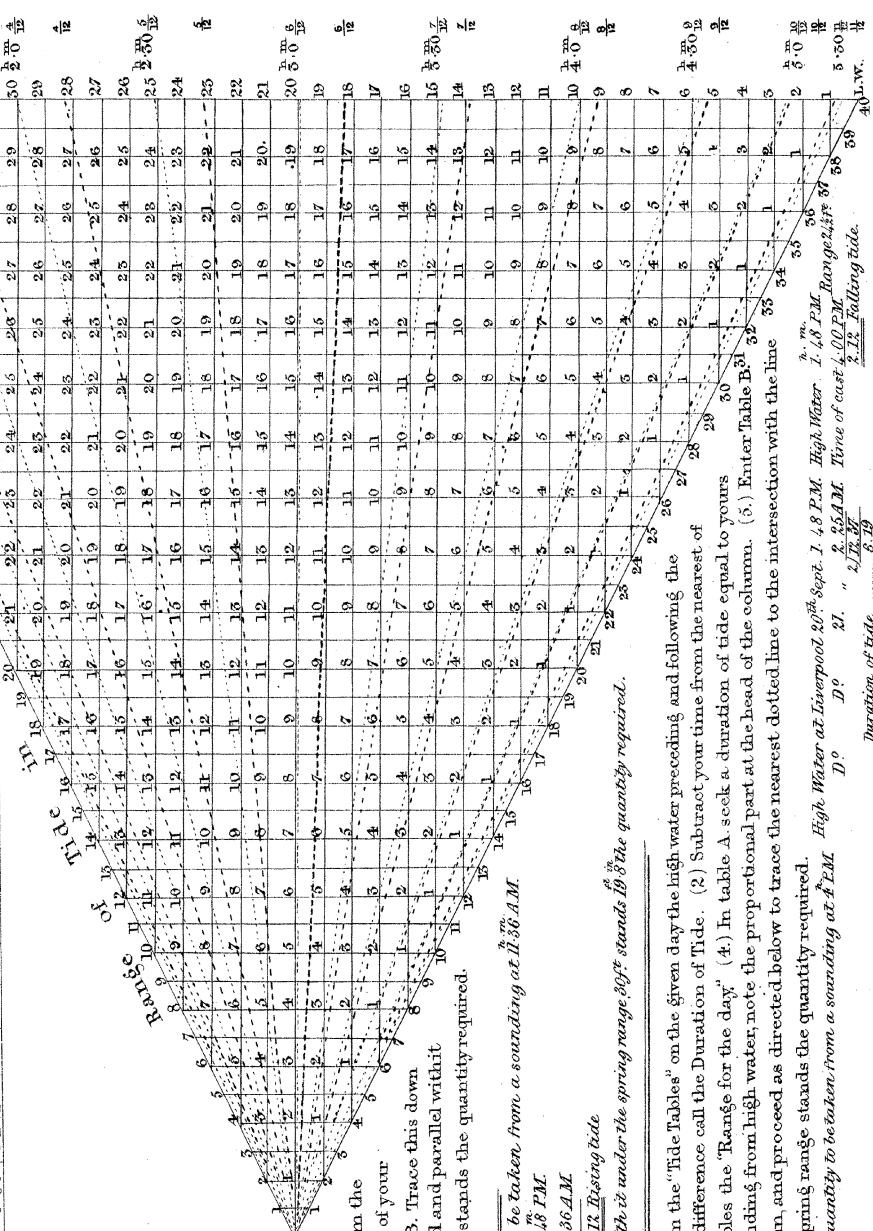


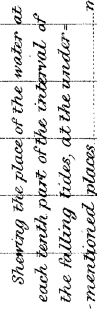
table A, opposite 6-19. ^{h. m.} 2-12 hulls about half way between $\frac{4}{12}$ and $\frac{6}{12}$ at the head of the column. In table B, under $2\frac{1}{4}$ feet range of tide and half way between $\frac{4}{12}$ and $\frac{6}{12}$ and parallel with it under

the spring range (from table C.) 30 feet stands 18th the quantity to be taken from the sounding.

Knowing the range for the day at Liverpool, the range for the day at any other place in the Irish Sea may be obtained approximately by the following rule.

EXAMPLE Required the range for the day at Bardson on the 8th September 1847 as 30 : 9 :: 22 : 30 feet, is to the range marked upon the tide chart, so is the range for the day as

$$30 / \frac{198}{6.770}$$



| At Holyhead. | Month. | 1838. | | 1839. | | 1846. | | 1847. | | Mean of months. | |
|-----------------------------------|--------------|-------|-----------------|-------|-----------------|-------|-----------------|-------|------------------|-----------------|------------------|
| | | ft. | in. | ft. | in. | ft. | in. | ft. | in. | ft. | in. |
| Apparent mean place of the water. | January ... | 11 | 3 $\frac{1}{4}$ | 10 | 6 | | | 10 | 7 | 10 | 9 $\frac{1}{3}$ |
| | February ... | 10 | 6 $\frac{1}{2}$ | 10 | 3 | | | 9 | 10 | 10 | 2 $\frac{1}{3}$ |
| | March | 10 | 1 | 10 | 2 | | | 10 | 4 | 10 | 2 $\frac{1}{3}$ |
| | April | 10 | 1 | 9 | 10 | | | 9 | 11 | 9 | 11 $\frac{1}{3}$ |
| | May | 10 | 2 | 9 | 9 | 10 | 0 $\frac{1}{2}$ | 9 | 11 $\frac{3}{4}$ | 9 | 11 $\frac{3}{4}$ |
| | June | | | 10 | 1 | 10 | 4 | 9 | 11 $\frac{3}{4}$ | 10 | 1 $\frac{1}{2}$ |
| | July | 10 | 1 | 10 | 1 $\frac{1}{2}$ | 10 | 1 $\frac{3}{4}$ | 9 | 10 $\frac{3}{4}$ | 10 | 0 $\frac{3}{4}$ |
| | August | 10 | 6 | 9 | 10 | 10 | 1 | 9 | 10 $\frac{3}{4}$ | 10 | 0 $\frac{3}{4}$ |
| | September . | 10 | 4 | 10 | 7 | 11 | 1 | 10 | 3 $\frac{1}{4}$ | 10 | 6 $\frac{3}{4}$ |
| | October ... | 10 | 6 $\frac{3}{4}$ | 10 | 3 $\frac{1}{3}$ | 10 | 8 | 10 | 10 | 10 | 7 |
| | November.. | 10 | 7 | 10 | 2 $\frac{1}{2}$ | 10 | 7 $\frac{3}{4}$ | 10 | 9 $\frac{3}{4}$ | 10 | 6 $\frac{3}{4}$ |
| | December.. | 10 | 7 | 11 | 2 | 10 | 6 | 10 | 11 | 10 | 9 $\frac{1}{2}$ |
| Mean of the year ... | | 10 | 5 | 10 | 2 $\frac{3}{4}$ | 10 | 5 $\frac{1}{2}$ | 10 | 3 $\frac{1}{4}$ | 10 | 3 $\frac{5}{8}$ |

Summer months.

All the tides of the Irish Sea partake of the nature of river tides in having their ebb longer than their flood, except those of Tuskar and Holyhead, which are the reverse. The respective intervals are given in the order in which the places occur.

| | | Rising. | | Falling. | | Duration of rising and falling tides. |
|-------------------|-------------------------------|---------|----|----------|----|---------------------------------------|
| | | h | m | h | m | |
| Duration of tide. | Tuskar | 6 | 27 | 6 | 08 | |
| | Bardsey | 5 | 24 | 6 | 52 | |
| | Holyhead | 6 | 18 | 6 | 00 | |
| | Peel, Isle of Man | 6 | 00 | 6 | 15 | |
| | Ramsay, Isle of Man | 5 | 48 | 6 | 35 | |
| | Fleetwood | 5 | 46 | 6 | 39 | |

All these are the mean of many observations.

The change at Holyhead is remarkable, and if we follow the durations up to Ramsay we shall see that Peel also, an intermediate station, is affected. The cause of this may possibly be connected with the effort of the water to maintain its level ; for in projecting the curve of the wave on paper, this peculiarity, in connection with the very short flood of Bardsey, has the effect of reducing the curve from what it would assume, were Holyhead similarly influenced with other places.

Remarkable deviation at Holyhead.

Probable cause.

The next peculiarity to which I shall direct attention is that of the form of the surface of the opposite sides of the channel at the instant of half-tide, and at the times of high and low water respectively at the virtual head of the channel. In Plate IV. I have given these sections of the water for the purpose of comparison. E is a section of the tide-wave at the *instant of high and low water* at Fleetwood ; the broken line being the *western* side of the channel, or a line drawn through Courtown on to Peel, Isle of Man ; the dotted line being through the *eastern* limit of the channel, or from Peel through Bardsey to Pembroke. F is a section of the water through the same localities at the *third hour* of the tide at Fleetwood ; the broken line in this case also representing the *western* portion of the channel, the dotted the *eastern*.

Form of the surface of the water on east and west sides of the channel at the same instants.

In these sections it will be seen what an unusual depression there is of the water-line between Holyhead and Bardsey, and as this occurs at the time of slack water throughout the channel, we may perhaps connect with it the inversion of the interval of tide before mentioned at the former place.

Curves of tide-waves of various ranges.

I conclude these remarks with directing your attention to another diagram, Plate V., exhibiting the curves assumed by the tide-wave in various parts of the Irish and Bristol Channels. They are given without any corrections having been applied to them.

Importance of the observations being extended.

Having now laid before you the result of our observations upon the tides of the Irish Sea, I wish to call your attention to the great importance of these observations being extended. Independent of the vast advantage of having a correct knowledge of the set of the stream at the entrance of two channels through which the greater part of the trade of this great maritime nation is conducted, I think I shall be able to show that in another point of view also, considerable interest attaches to the subject.

Attempt to trace the course of the stream, and connect the tides of the Irish Sea with those of the English Channel.

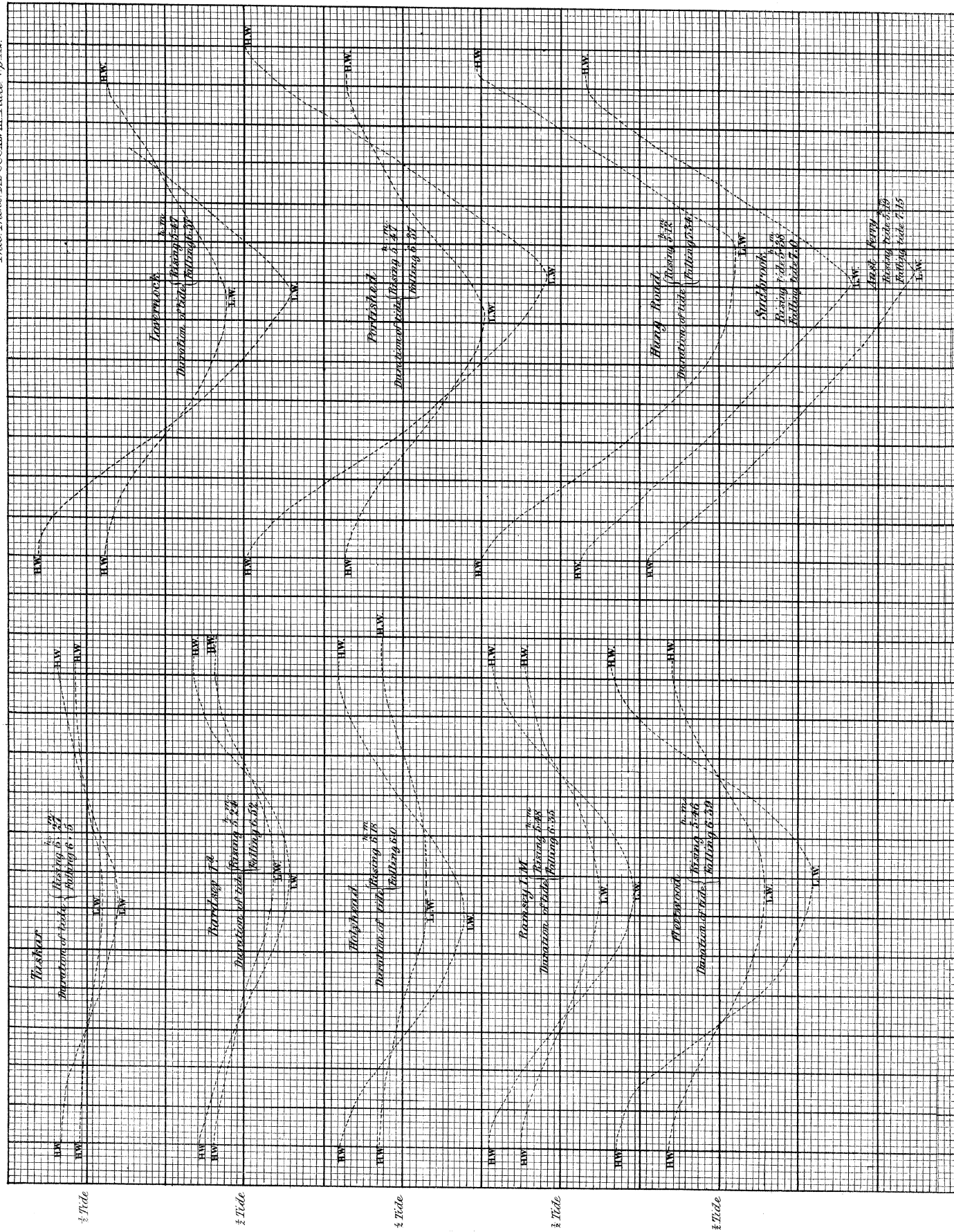
That you may meet the question at once, I lay before you the result of an attempt I have made with the aid of the data we already possess, and especially those of Capt. MARTIN WHITE, R.N., to trace the course of the stream from Pembroke to the Land's End; to connect the tides of the Irish Sea with those of the Bristol and English Channels, and finally with those of the offing; or, in other words, to reconcile and reduce to a system the anomalous and apparently contradictory observations of our naval surveyors in that portion of our coast, by combining them with the information which the recent attention to the tides has already furnished.

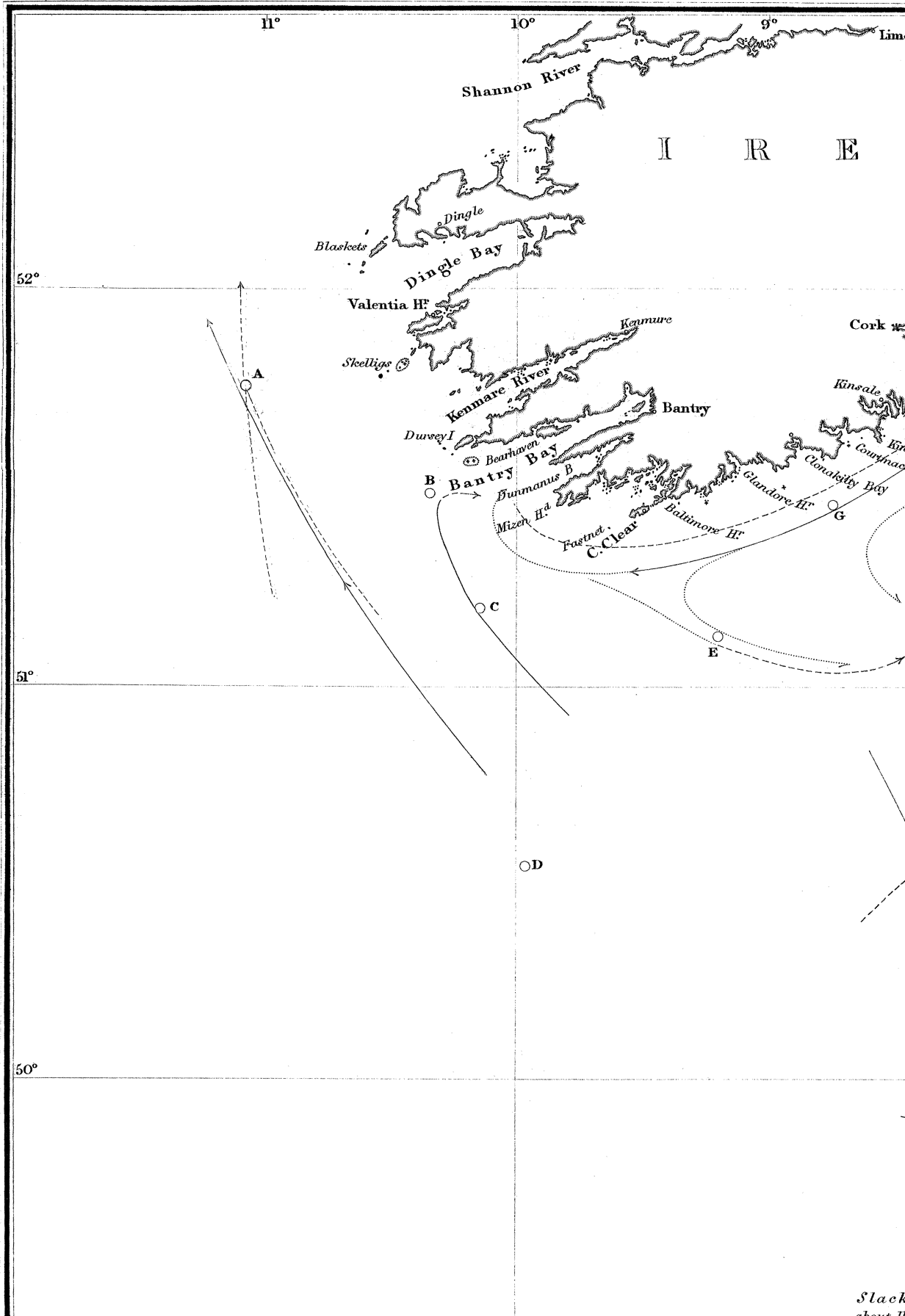
Difficulty of so doing.

The first part of this attempt presented but few difficulties as the streams were tolerably regular, but for the last our data, at first sight, seemed to bar all progress. At the mouth of the English Channel especially, opposition presented itself at every step; the observations projected upon the chart exhibited a frieze of arrows pointing in all directions "in happy discordance," and certainly quite useless and unintelligible to the navigator. Relying however upon the general accuracy of the observations, I was encouraged to proceed. After some consideration it seemed evident that the water was influenced by forces acting in opposition nearly to each other, and that there was a tide in the offing whose streams of ebb and flood did not correspond with those of the channels. By applying this idea first to the English Channel, I found the observations responded to it; and carrying it to the offing of the Irish Sea, and considering that channel as comprising the Bristol Channel within its limits, as the English Channel does the Gulf of St. Malo, I had the satisfaction of finding the correctness of the idea confirmed so far as the observations themselves extended. This offing stream appears to be of great extent, setting to the north and south along the coast of Biscay and the British Isles, running six hours nearly each way, and exercising an influence with more or less effect over all the waters of the channels and estuaries it passes in its progress, diverting their courses, and in some

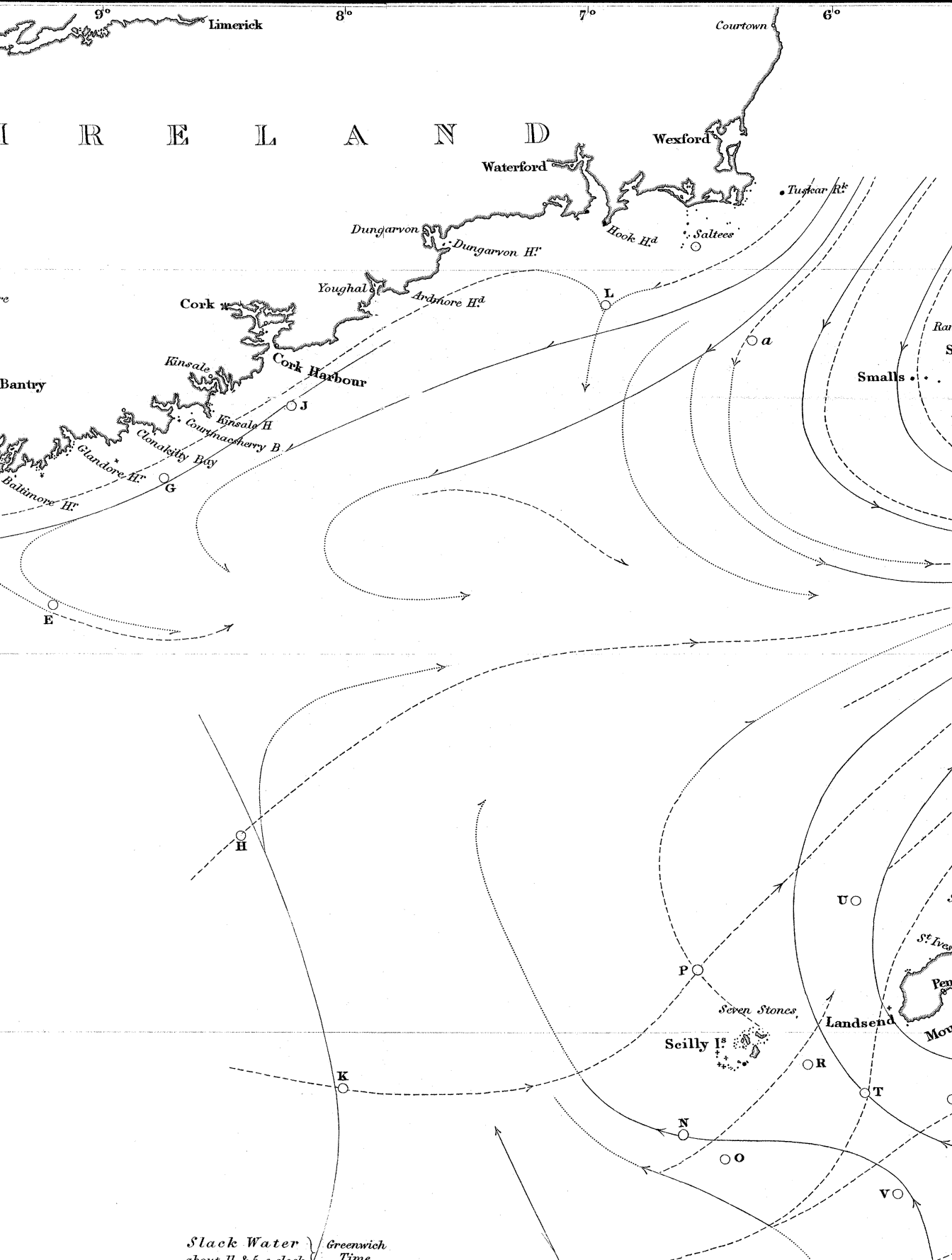
Discrepancies reconciled by the application of an offing stream setting in opposition nearly to that of the channel stream.

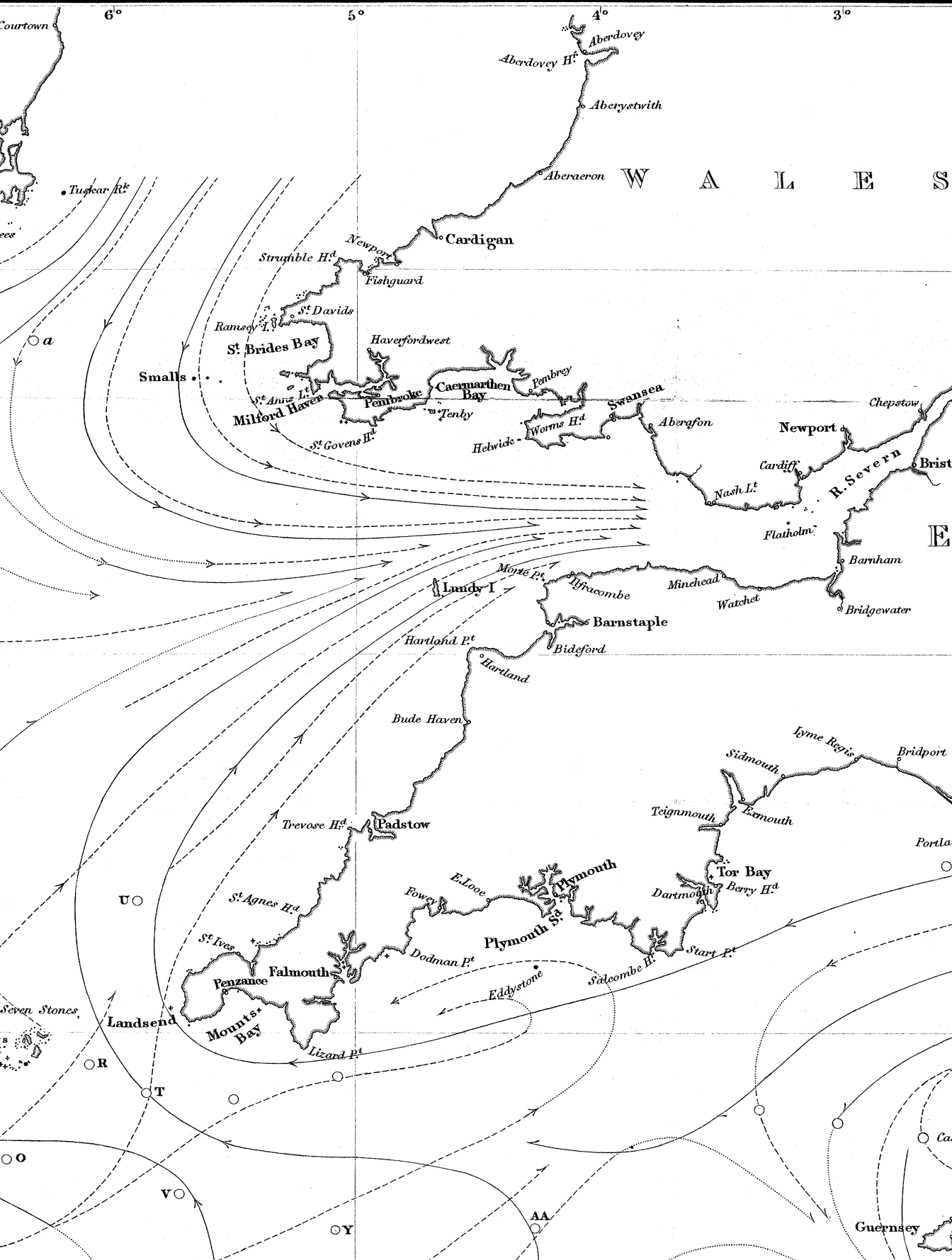
Showing the curve of the Tide Wave at springs and neaps in the Bristol Channel and Irish Sea.





Slack
about





3°

2°

1°

0

TIDE CHART

of the

ENGLISH, IRISH AND BRISTOL CHANNEL

L E S

SHEWING THE SET OF THE STREAMS

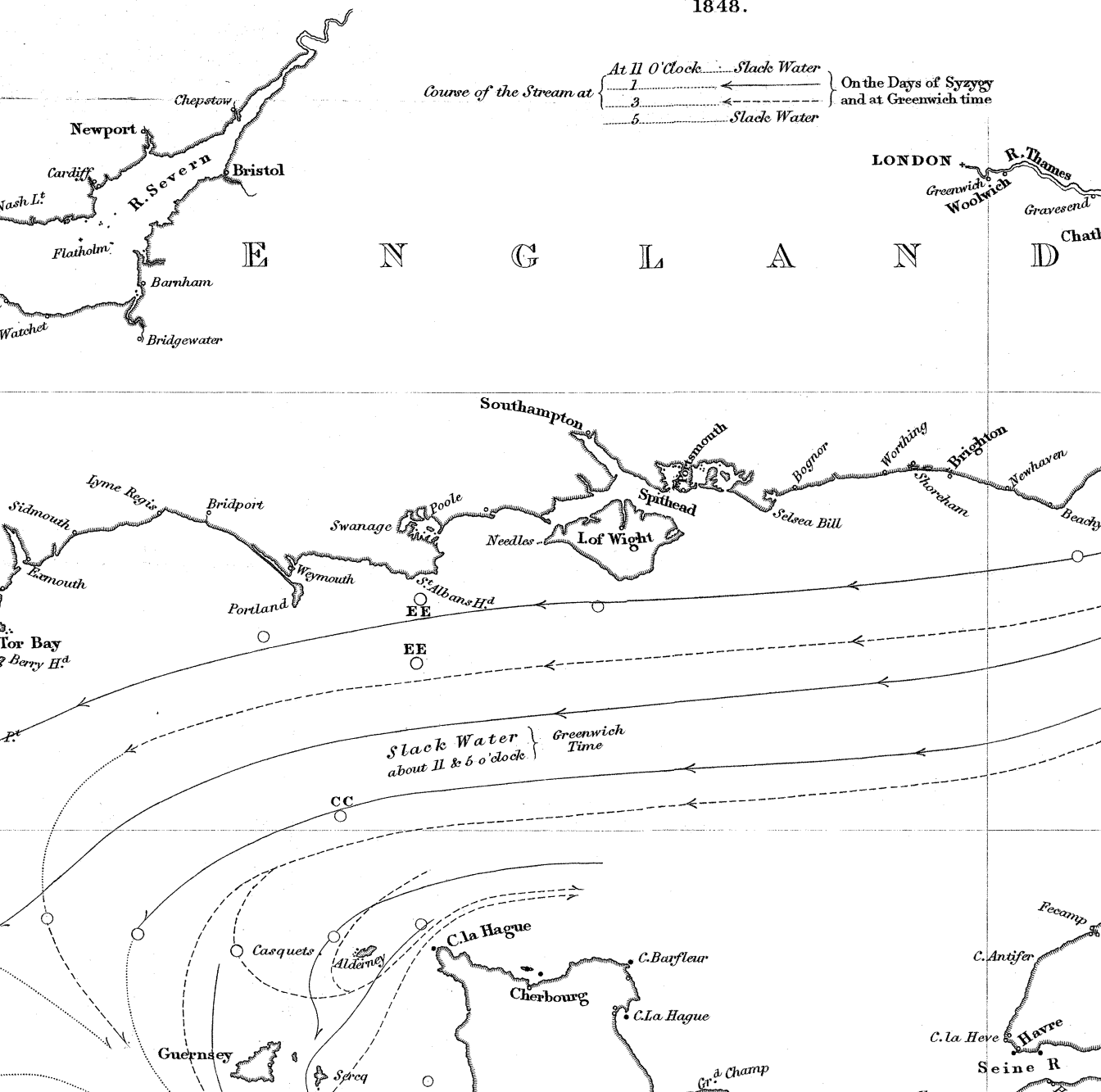
in each

AT THE SAME INSTANTS OF TIME

of the **OUTGOING** tide

BY CAPTAIN F.W. BEECHEY R.N. F.R.S.

1848.



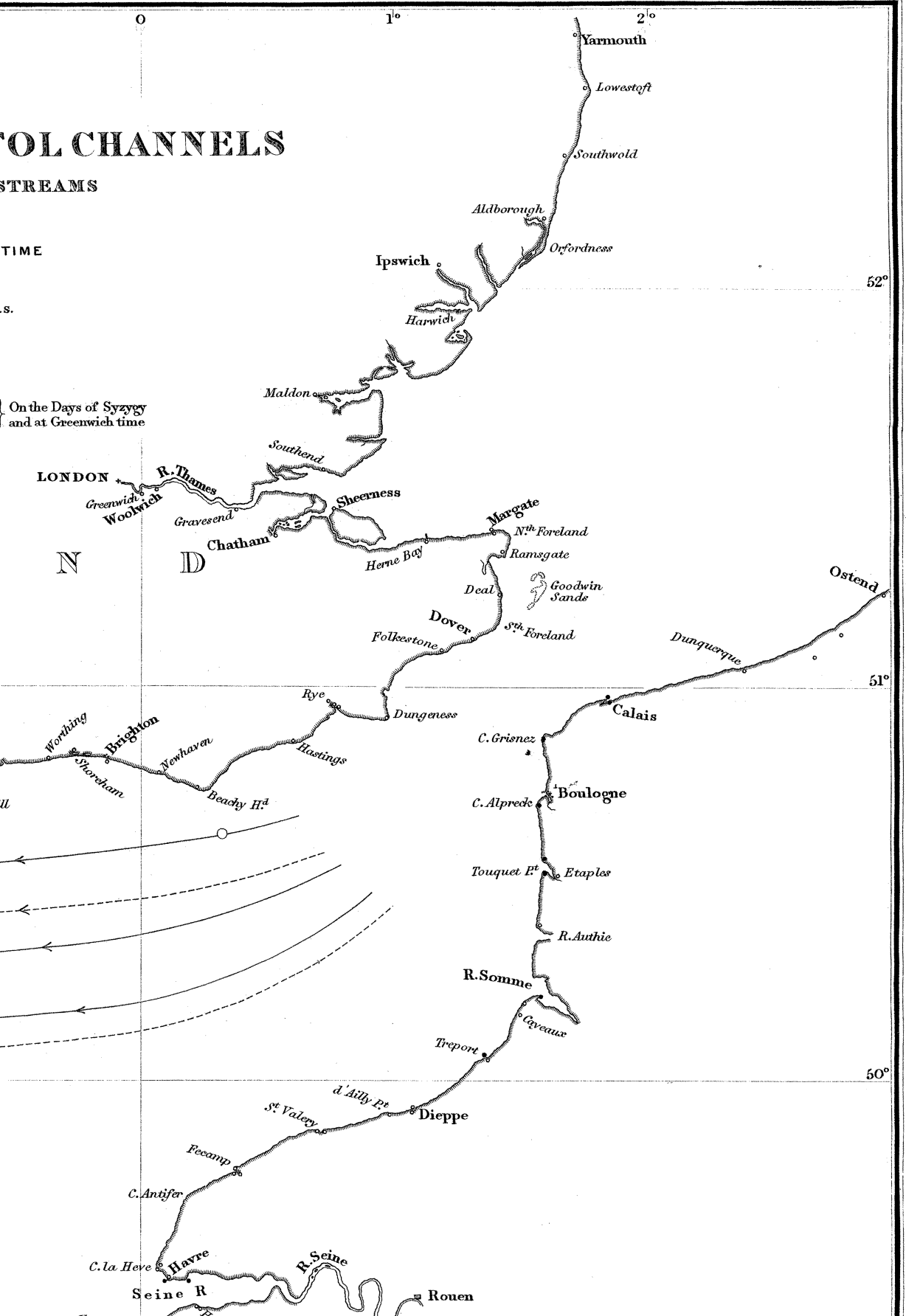
TIDAL CHANNELS

STREAMS

TIME

S.

On the Days of Syzygy
and at Greenwich time



51°

50°

49°

11°

10°

9°

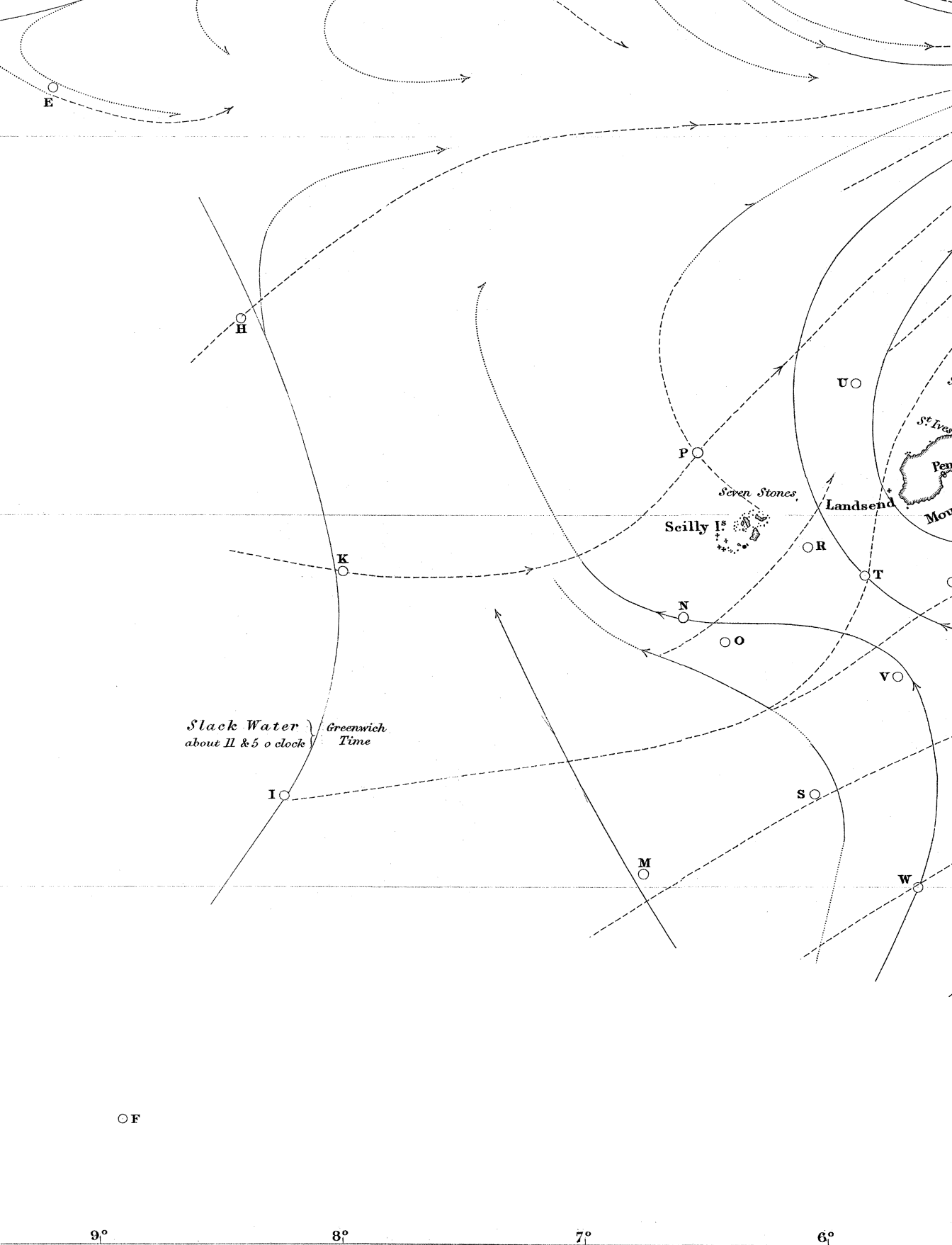
C

E

D

F

*Slack
about 12*



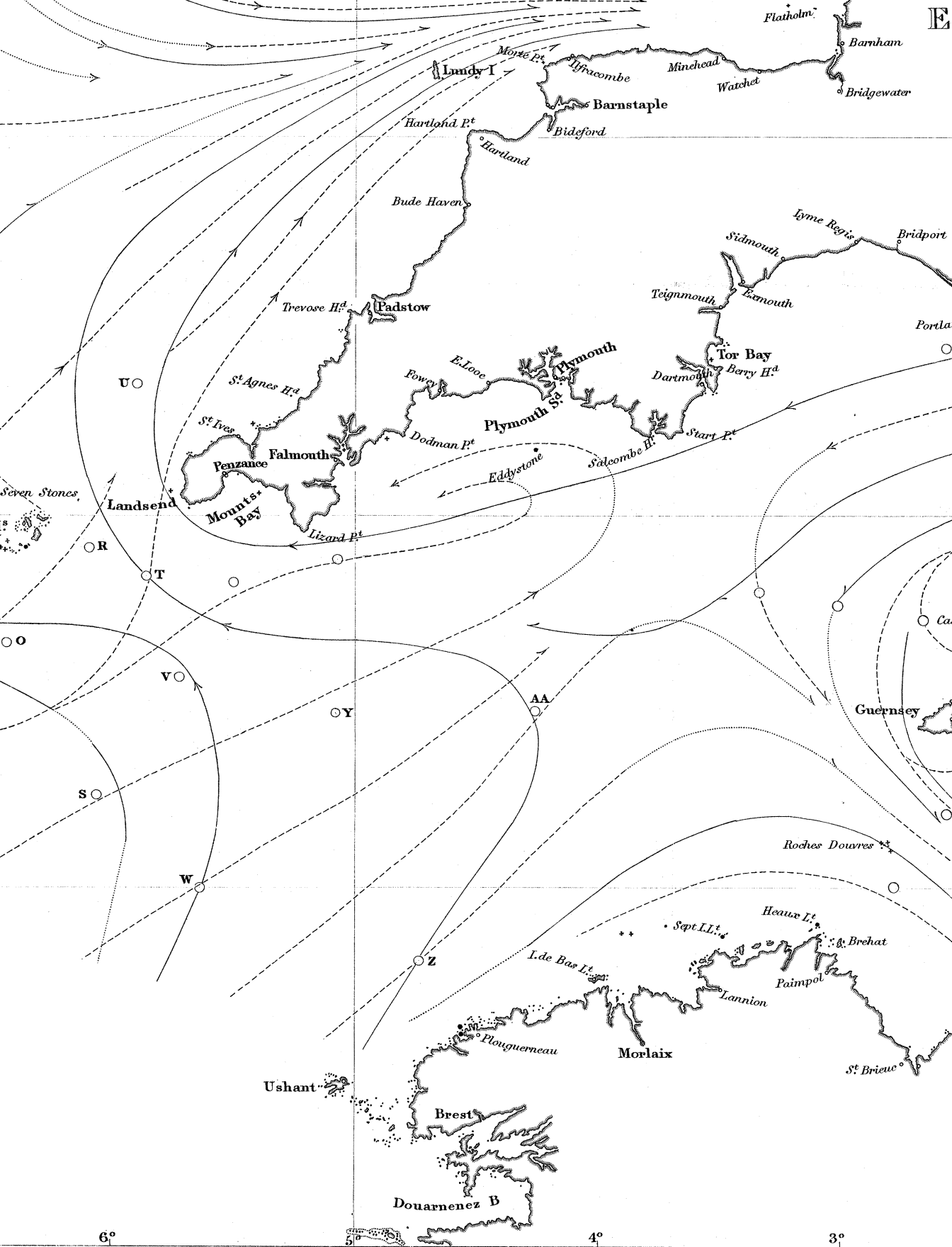
○F

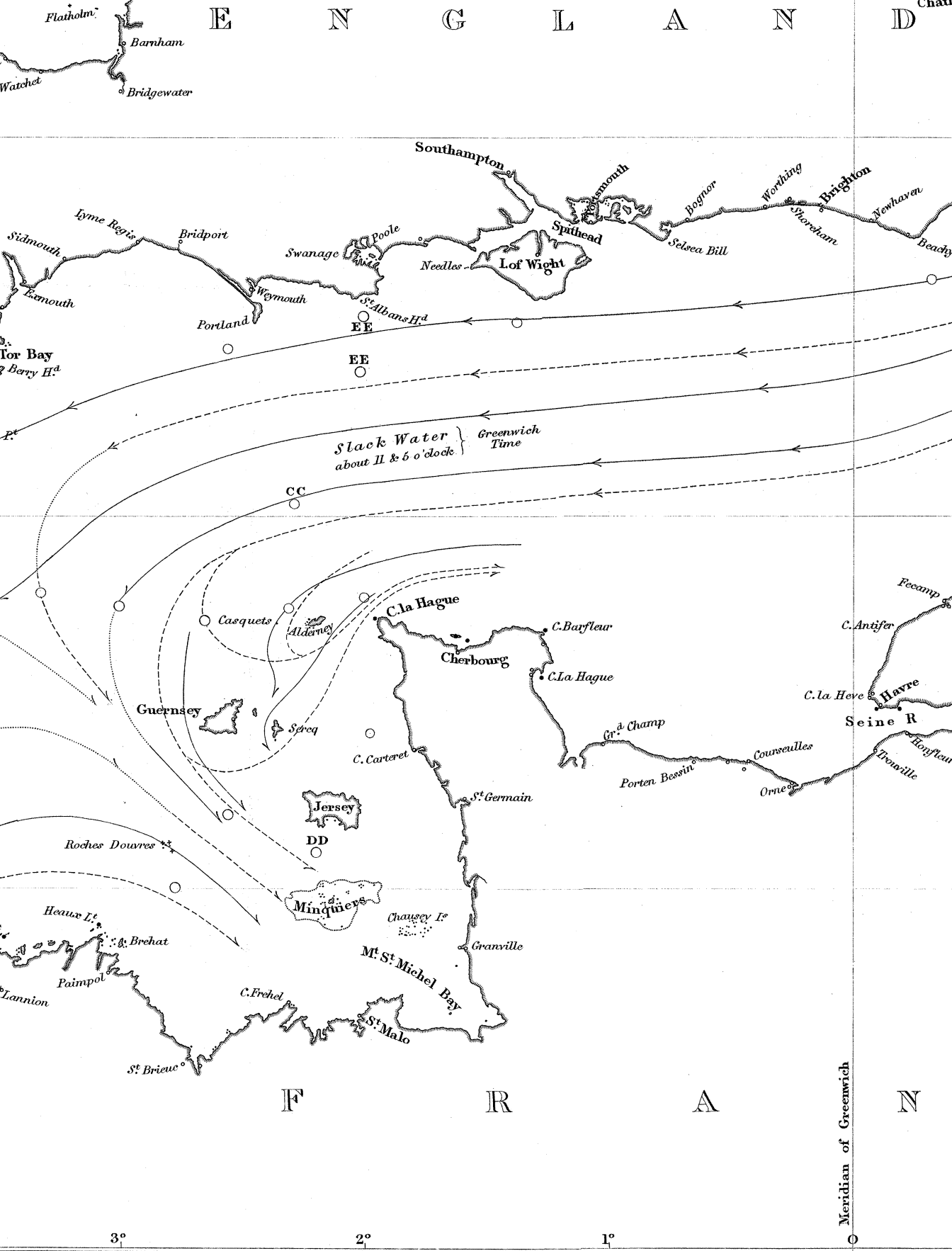
9°

8°

7°

6°



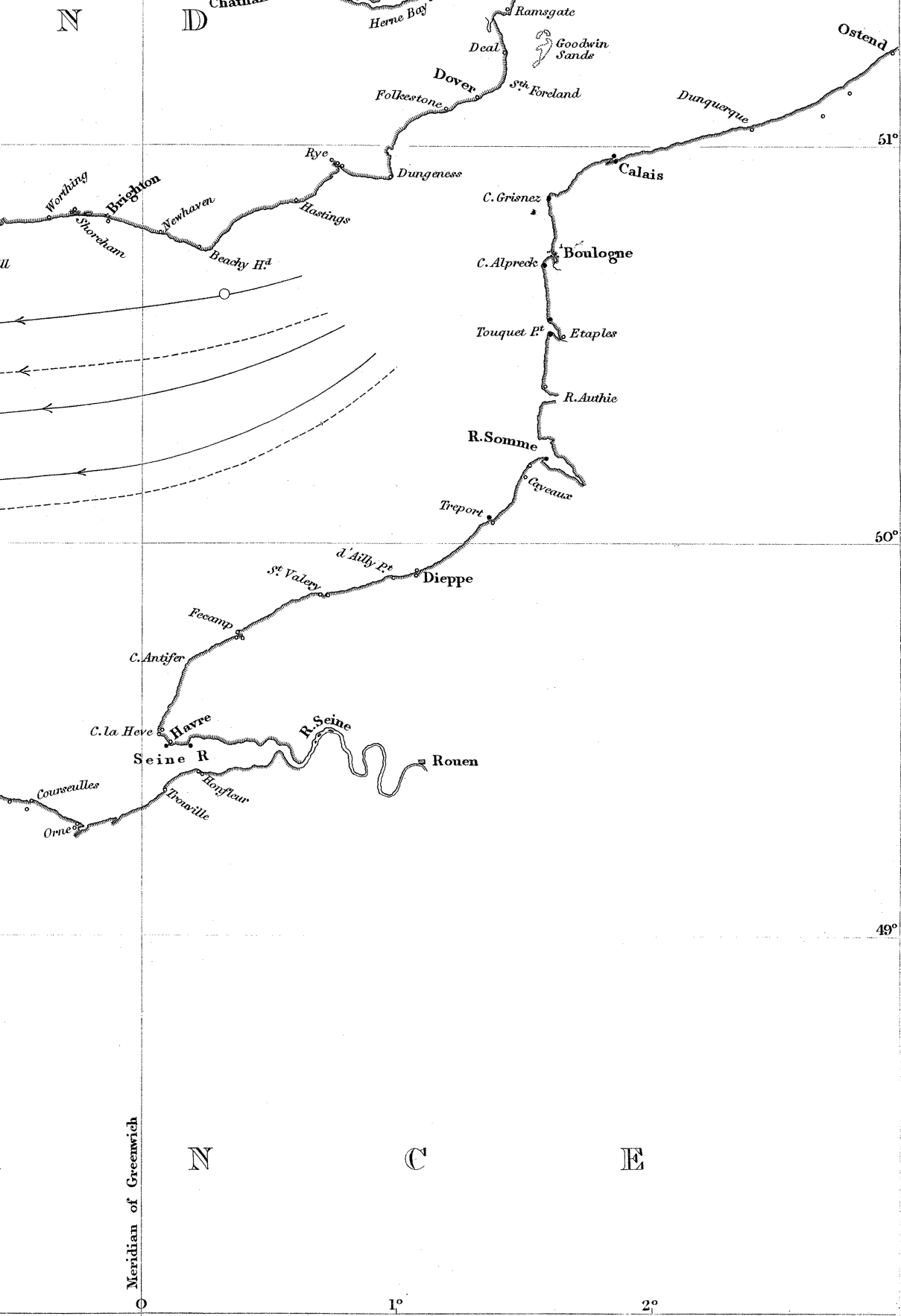


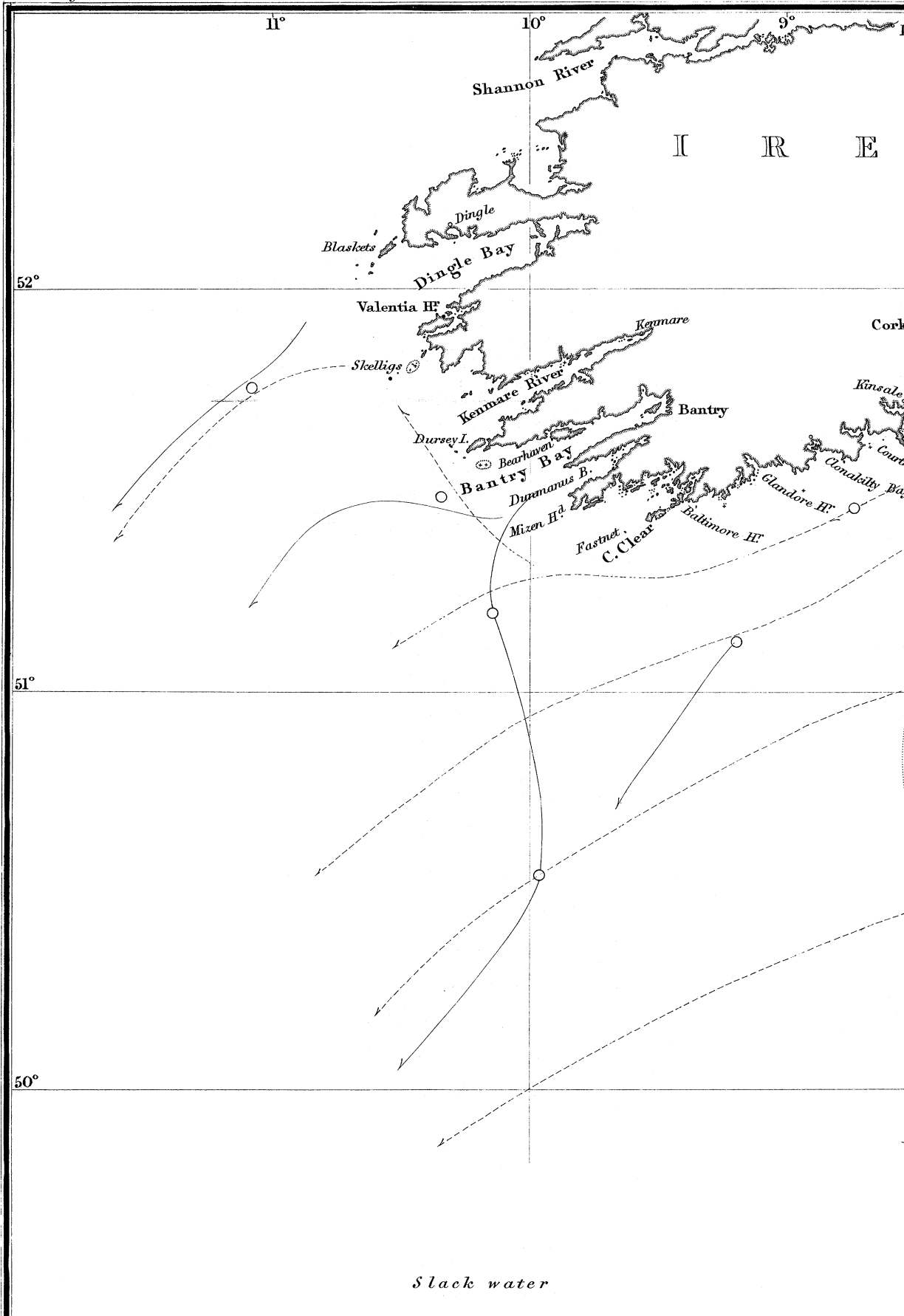
3°

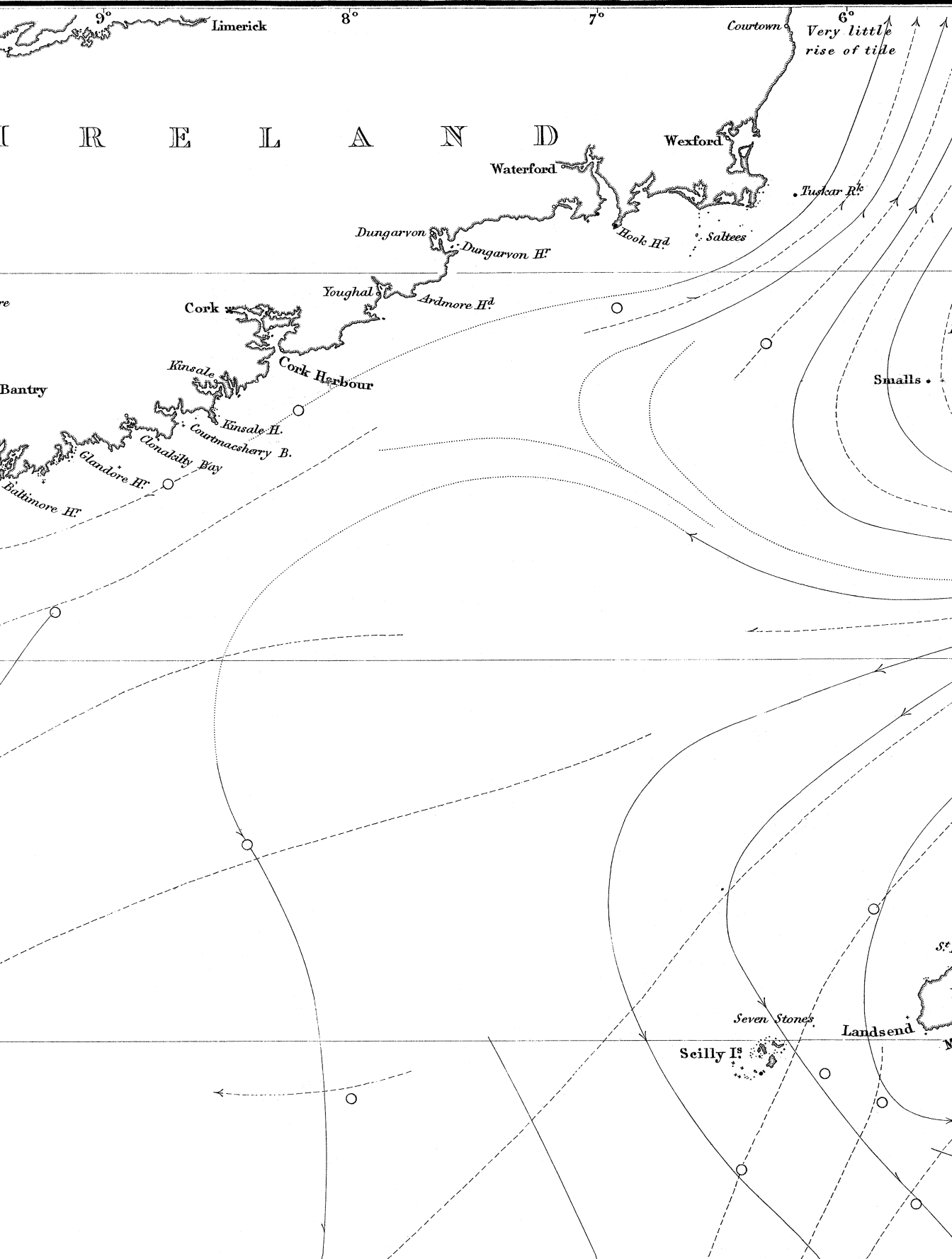
2°

1°

Meridian of Greenwich







9°

Limerick

8°

7°

6°

Courtown

Very little
rise of tide

IRISH

Wexford

Waterford

Tuskar Rk

Dungarvon

Dungarvon H^r

Hook H^d

Saltees

Youghal

Ardmore H^d

Cork

Cork Harbour

Kinsale

Kinsale H.

Courtmacsherry B.

Donaghadee Bay

Glandore H^r

Baltimore H^r

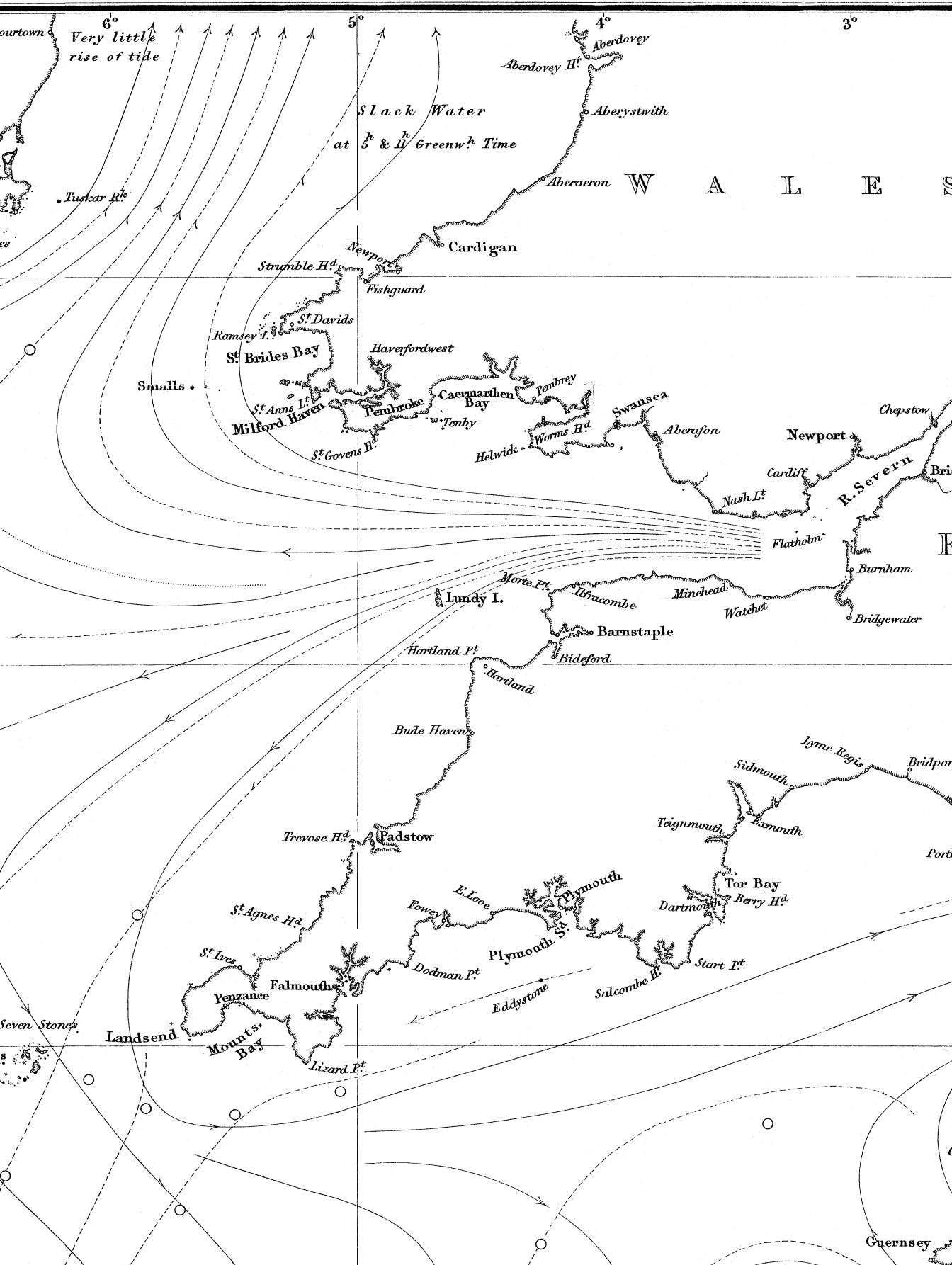
Bantry

Smalls

Seven Stones

Seilly I^s

Landsend



3°

2°

1°

0

TIDE CHART of the ENGLISH, IRISH AND BRISTOL CHANNEL

L E S

SHEWING THE SET OF THE STREAMS

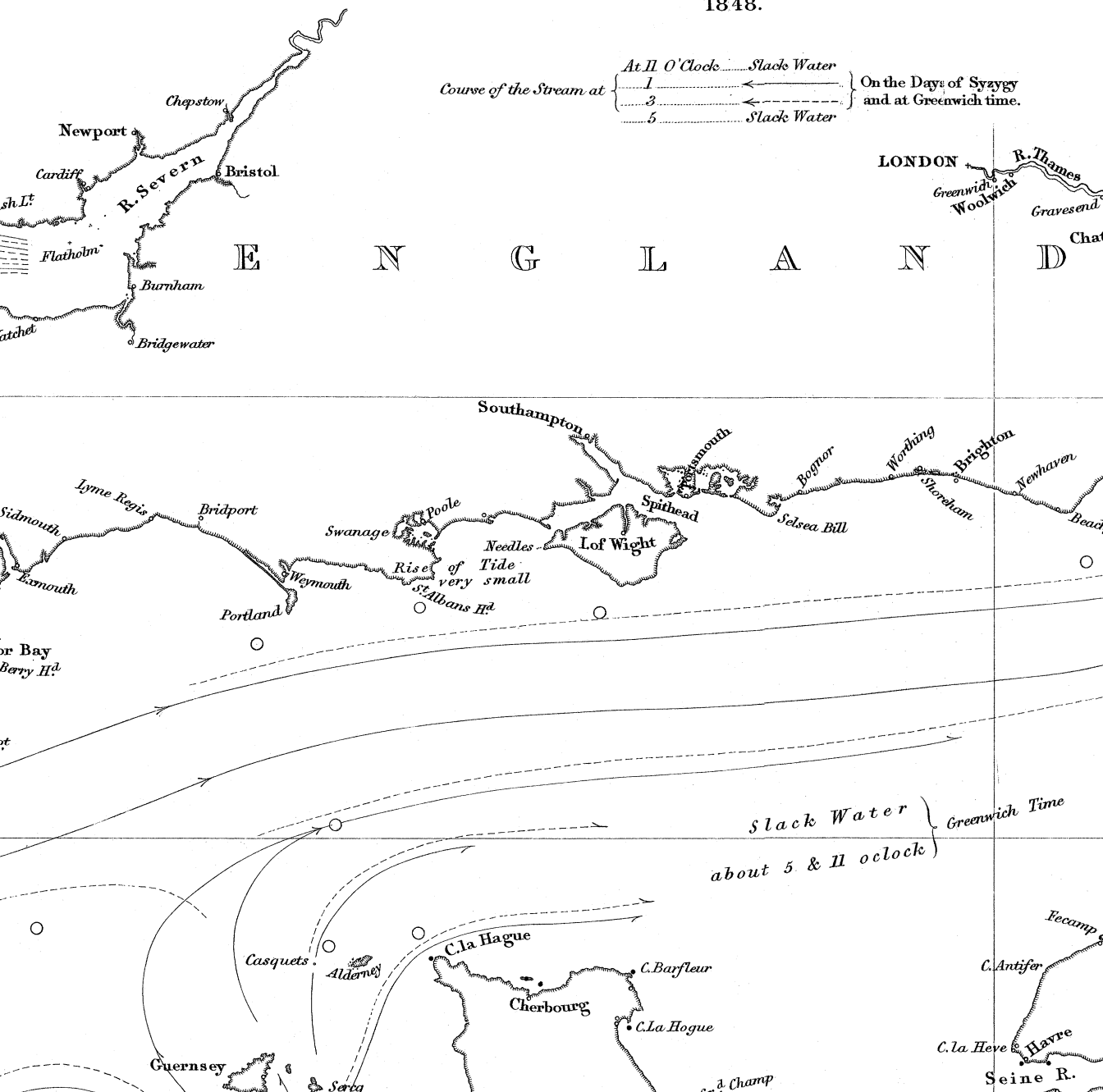
in each

AT THE SAME INSTANTS OF TIME

of the **INGOING** tide

BY CAPTAIN F.W. BEECHEY R.N. F.R.S.

1848.



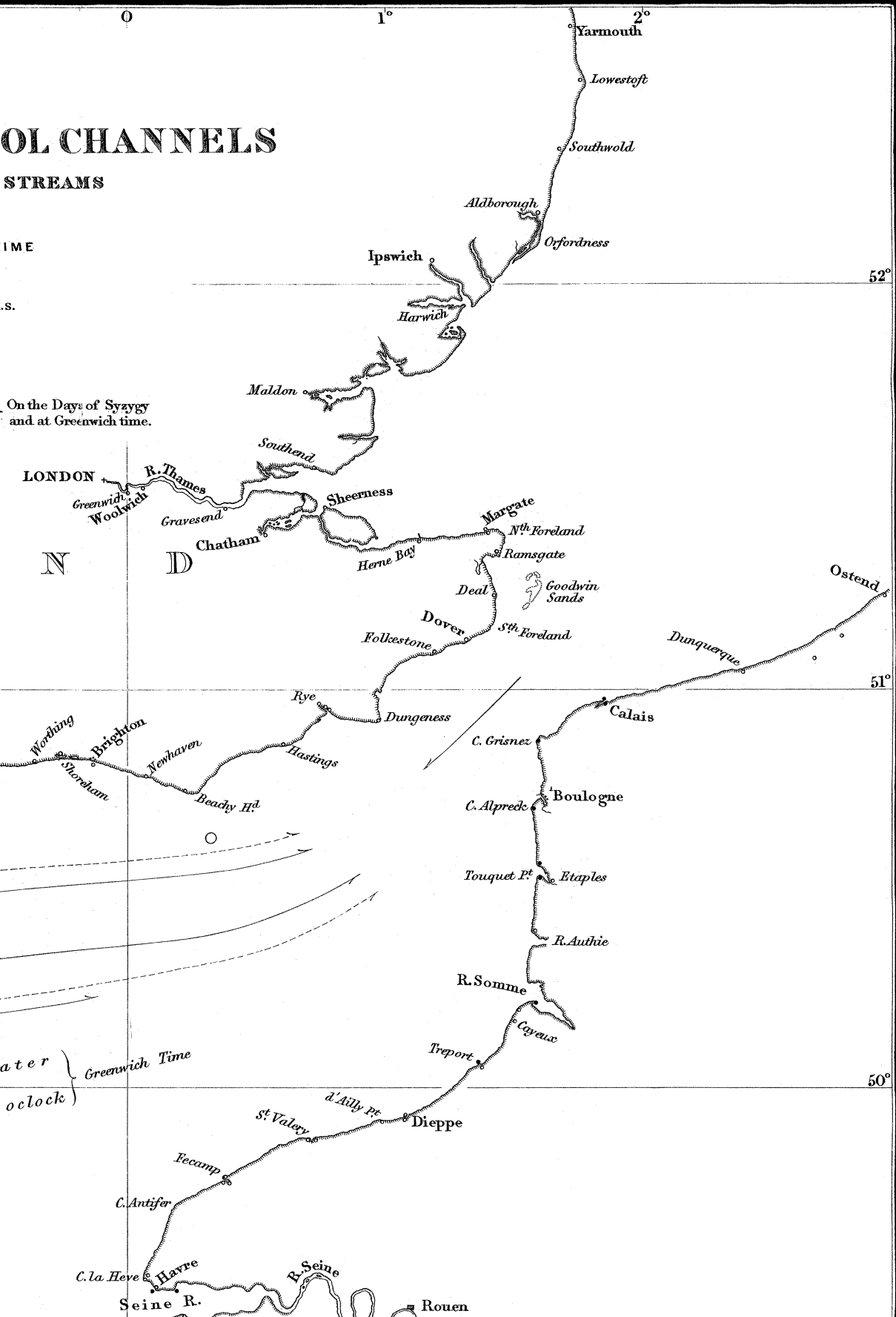
TIDAL CHANNELS

STREAMS

TIME

.S.

On the Days of Syzygy
and at Greenwich time.



after } Greenwich Time
oclock }

51°

50°

49°

11°

10°

9°

Slack water

about 5 oclock } *Greenwich Time*
and 11 oclock }

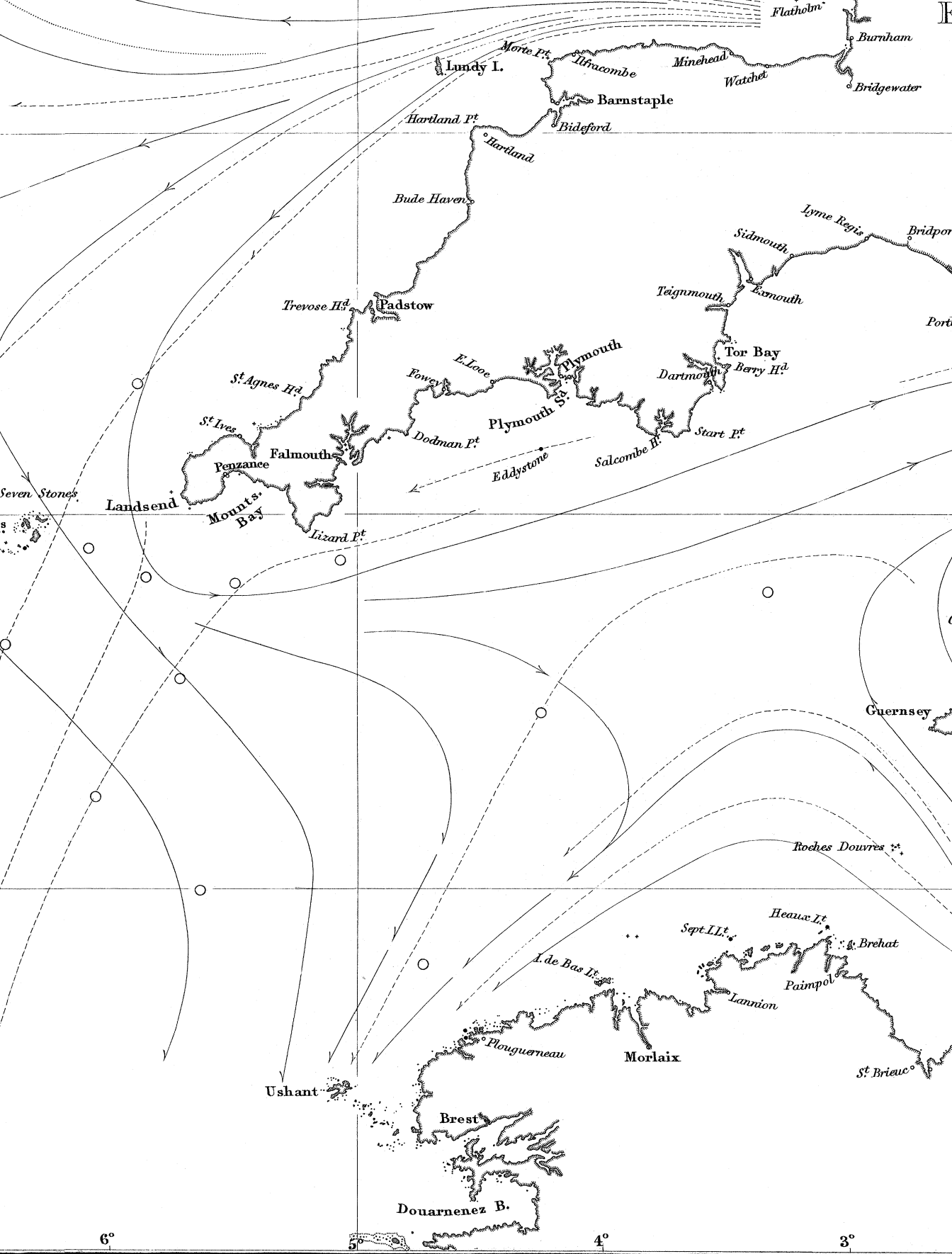


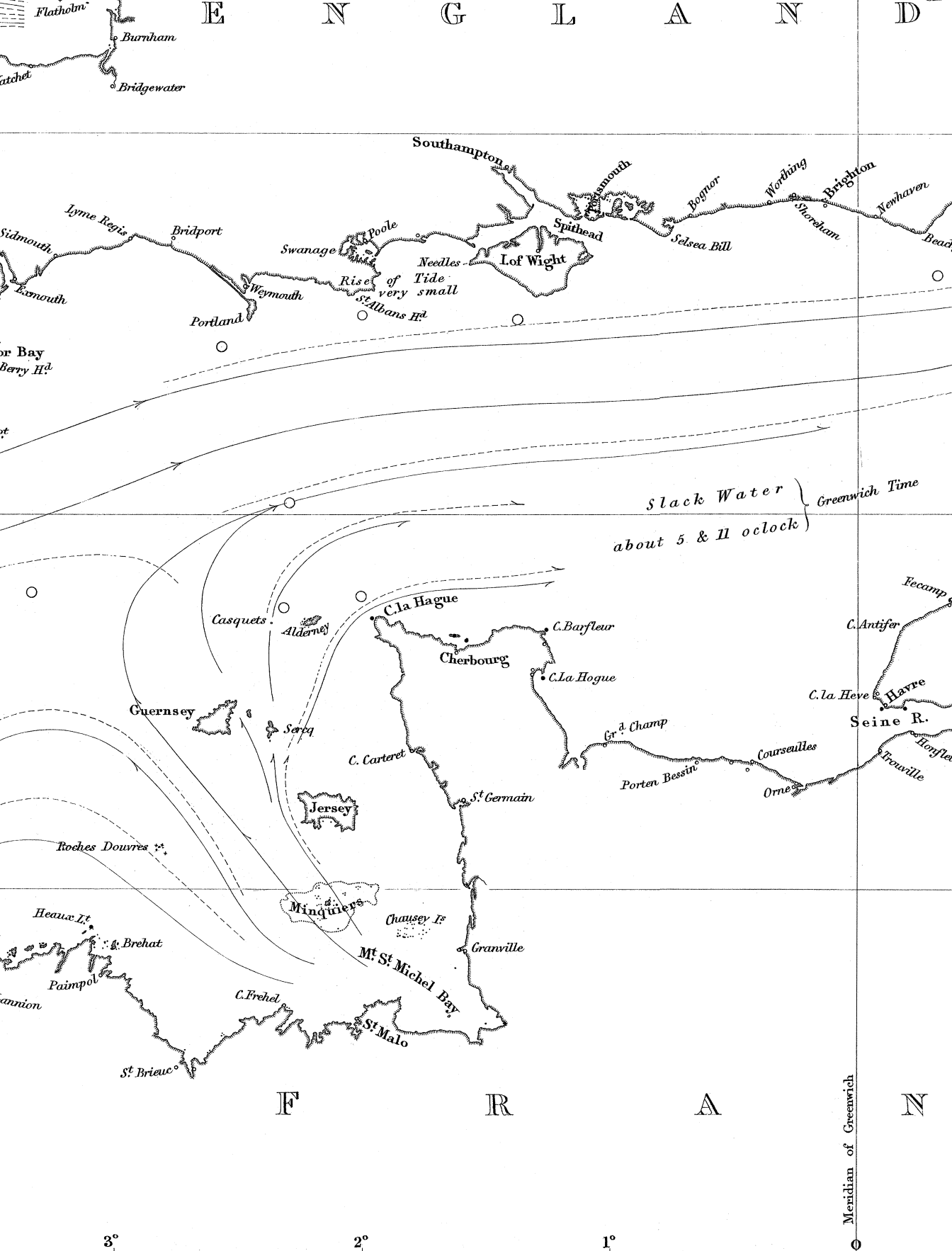
9°

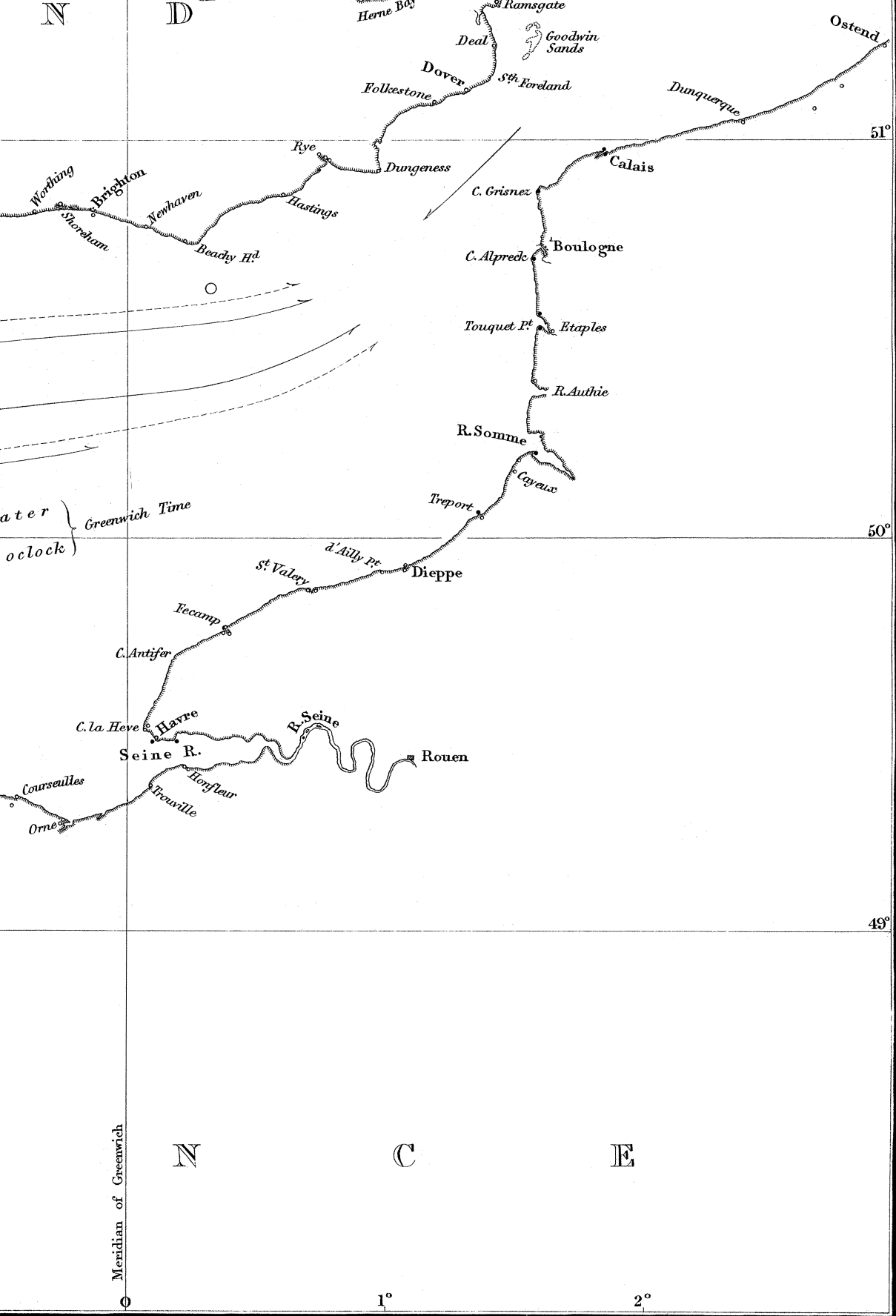
8°

7°

6°







cases, when the streams oppose, wholly overpowering or reversing their direction. That you may the more readily comprehend this explanation, I annex two charts, Plate IX. and X., upon which I have traced the course of the stream at *alternate hours* of a spring tide, each line representing the direction of the stream *at the same moment throughout both channels*. From the connection of the observations of the Irish Sea with those of the Bristol Channel, it is clear that the whole of the ebb or outgoing stream of the eastern half of the Irish Channel runs into the Bristol Channel, and forms the flood or ingoing tide of the northern half of that great estuary; and *vice versa*, the ebb or outgoing stream from the northern half of the Bristol Channel, forms the flood of the Irish Sea, each tide passing to and fro with great rapidity round St. Govan's Head. The centre and southern half of the Bristol Channel receive their waters from the offing and the English Channel, the coast stream bringing the waters up from the Land's End and the English Channel, as the stream on the northern half did those of the Irish Channel, and *vice versa*.

Influence of offing stream over that of the channel.

Courses of the stream at alternate hours of the tide, from Dungeness to the Irish Sea.

Tides of the Bristol Channel.

The great offing stream at the entrance of the English Channel extends its influence as far up as Cape La Hague, beyond which, owing perhaps to the sudden contraction which there occurs in the Channel, the stream suffers no interruption, but, as in the Irish Sea, passes up and down the Channel six hours nearly each way as far as a line joining Dungeness and Cape Grisnez, the apparent *virtual head* of the tidal channel. Here the influence of the North Sea stream begins to be felt, and here, as in the Irish Channel, again *the time of high and low water at the virtual head of the tide regulates the turn of the up and down stream along the whole channel* as far as the contraction. Beyond this the offing stream being governed by its own high water, and that occurring at about six hours earlier than that of the head of the channel, the offing stream either butts against the returning streams from the channels, or withdrawing its water, solicits their streams and thus alters their course, making them for the most part set across the Channel in curves more or less bent as the spot is more or less removed from the offing; so that there seems to be but one hour's tide each way that passes clean down the Channel from Beachy Head to Scilly, and round the Land's End to Bristol. The outgoing stream from Beachy Head encounters the ingoing stream of the offing tide somewhere about the Start Point, and both are turned down into the great Gulf of St. Malo, which seems to receive the accumulated waters of these opposite tides.

Effect of the offing stream upon the tide in the English Channel.

Meeting of the streams.

Whether or not this influx is instrumental in raising the water here to the extraordinary height of forty-seven feet perpendicular range at springs, or whether it be owing to its form and position as regards the advancing tide-wave, I leave to those who are competent to decide; but it is a coincidence that cannot escape observation, that this spot, like the Bristol Channel, is the concentration of streams from opposite directions; that it has its waters raised to the same extraordinary elevation nearly to a foot, and that its time of high water is nearly the same.

On the change of tide, this great bay, like the Bristol Channel, as it received so it

Gulf of St.
Malo tide.

returns its waters in opposite directions; the tide splitting somewhere between Alderney and the Start. But here especially, as also in a similar locality in the Irish Channel, we are in want of observations, and it is very unfortunate that this spot, which from its peculiarity is the most interesting of any in the English Channel, should be so completely deficient; for it seems most evident that the tidal streams meet off here, running together at one time and separating at another.

Such appears to be the explanation of the complicated motion of the waters at the entrances of these two great channels, and of the course of the stream in the English Channel above the contraction of the strait.

In tracing these streams, it was impossible not to be impressed with the many coincidences which assimilate the tidal phenomena of the two channels, so much so as to render it probable that they are subjected to precisely the same laws. As I feel confident that the consideration of this subject will be both interesting and useful, I shall endeavour to trace the resemblance through its several varieties.

Comparison
of the tidal
phenomena
of the En-
glish and
Irish Chan-
nels.

First, I shall consider the Irish Channel to extend, as above mentioned, from a line joining the Land's End and Cape Clear to the end of the tidal flow, which is either at Morecombe Bay or Peel in the Isle of Man; and the English Channel as reaching from a line connecting Ushant with the Land's End, to the end of its tidal flow, or to Dungeness. We shall then see that the English Channel from its outer limit to the end of its tidal stream is 262 geographical miles, and that the Irish Channel from its western limit to the end of its tidal stream, is nearly the same, being about 265 geographical miles. In both channels the stream enters from the southwest, and flows up until stopped by a counter stream. In both channels there is a contraction of the strait almost midway, by the promontories of Cape La Hague in one instance, and St. David's Head in the other, and at very nearly the same distances from the entrance. This contraction is, in both cases, the commencement of the regular stream, which flows six hours nearly each way, the *turn of the stream throughout coinciding with the times of high and low water at the virtual head of the channel*, situated in both cases about 145 miles above the contraction, and that time being very nearly the same, viz. 10^h 50^m at F and C*. Below this contraction, away from the land, the stream in both cases varies its direction nearly every hour, according to the force exerted upon it by the opposing offing stream.

In both cases, between the contraction and the southern horn of the channel, there is situated a deep estuary, the Bristol Channel and the Bay of St. Malo, in which the times of high water coincide, and where, in both cases, the opposing streams meeting in the channel, pour their waters into these gulfs, and where the tides in both places rise to the extraordinary elevation of forty-seven feet at the syzygies. From the Land's End to the meeting of these streams in the Bristol Channel is seventy-five miles, and from Brest to the meeting of the streams off Guernsey the same. A still further coincidence is apparent between the phenomena of these channels. In one,

* See Plate XI.

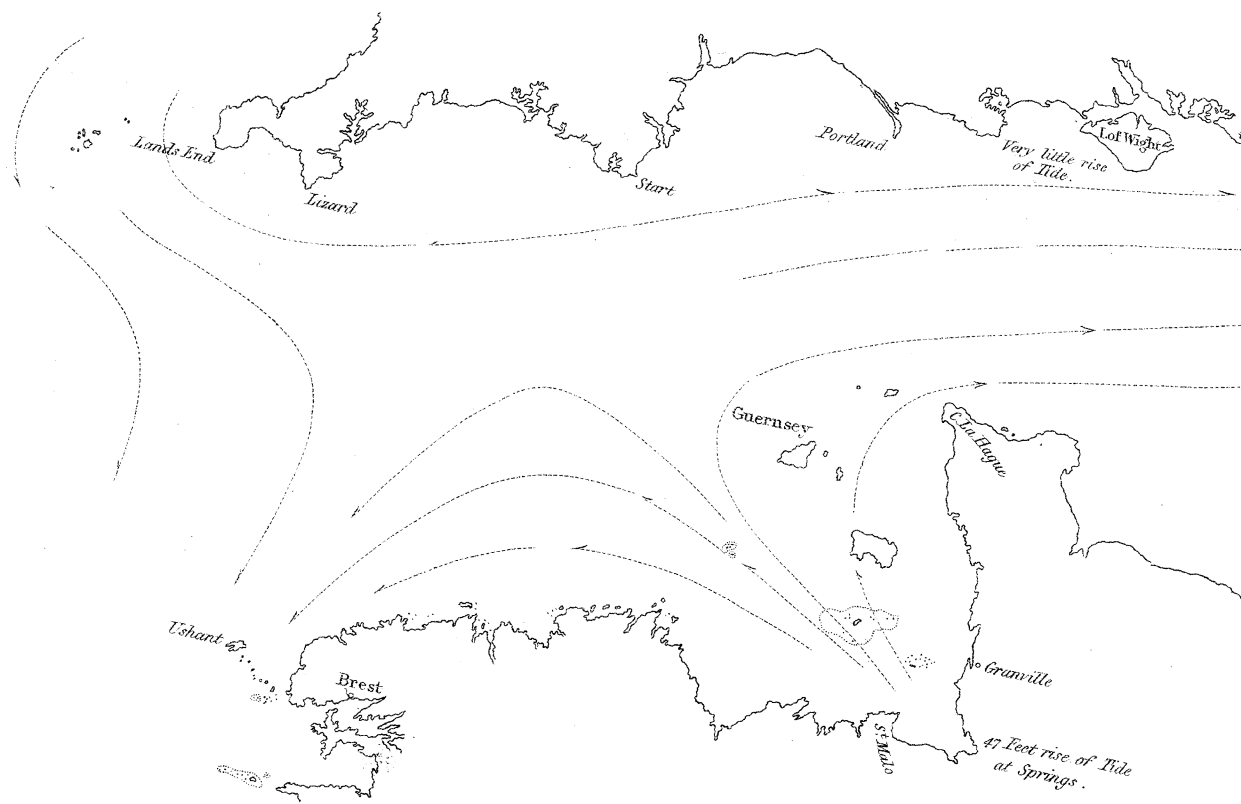
SKETCH
of the Course of the 7 o'Clock stream of Tide
 in the
English and Irish Channels.

To accompany a letter to the Hydrographer.

By Captain F.W. Beechey R.N.

1848.

E N G L A N D

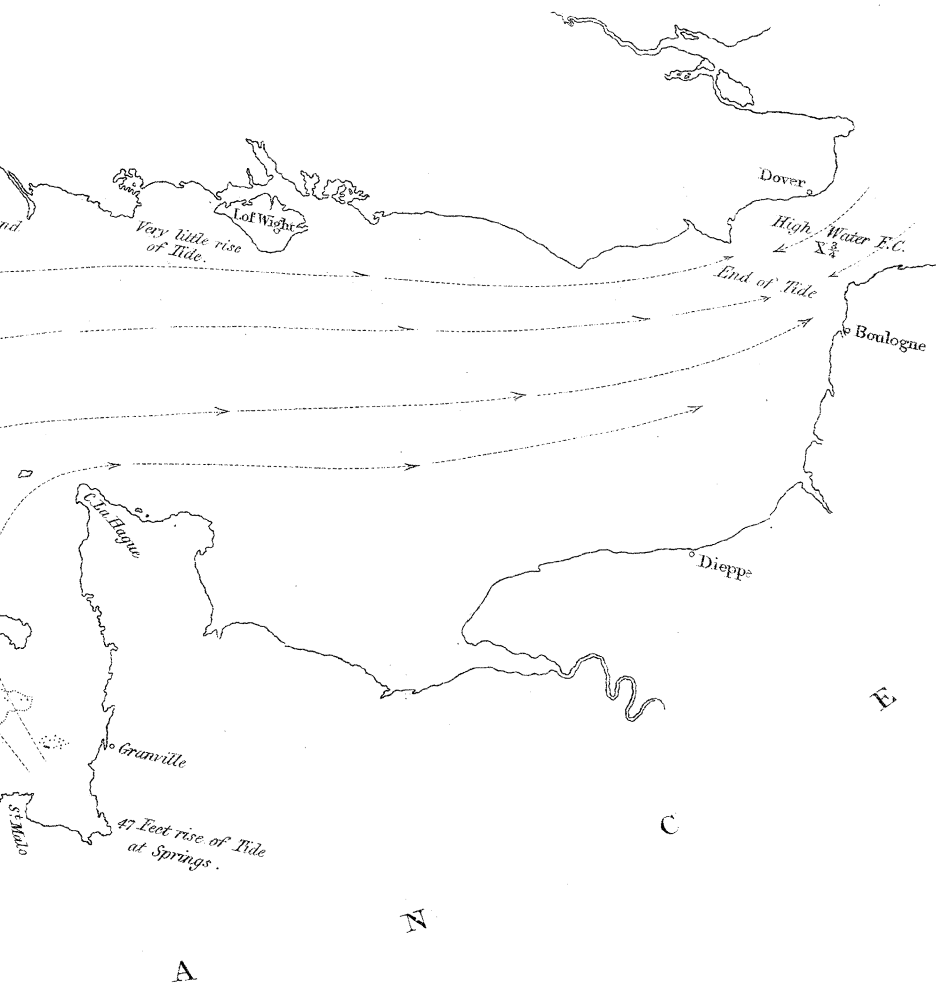


F R A

of Tide

ls.

L A N D



0 50 100
Scale of Miles.

I R E L A

C. Clear

Dublin

Quartern

Little or no rise of Tide

Tasker

St Davids

BRISTOL CHANNEL

W

47 Feet rise of Tide at Springs.

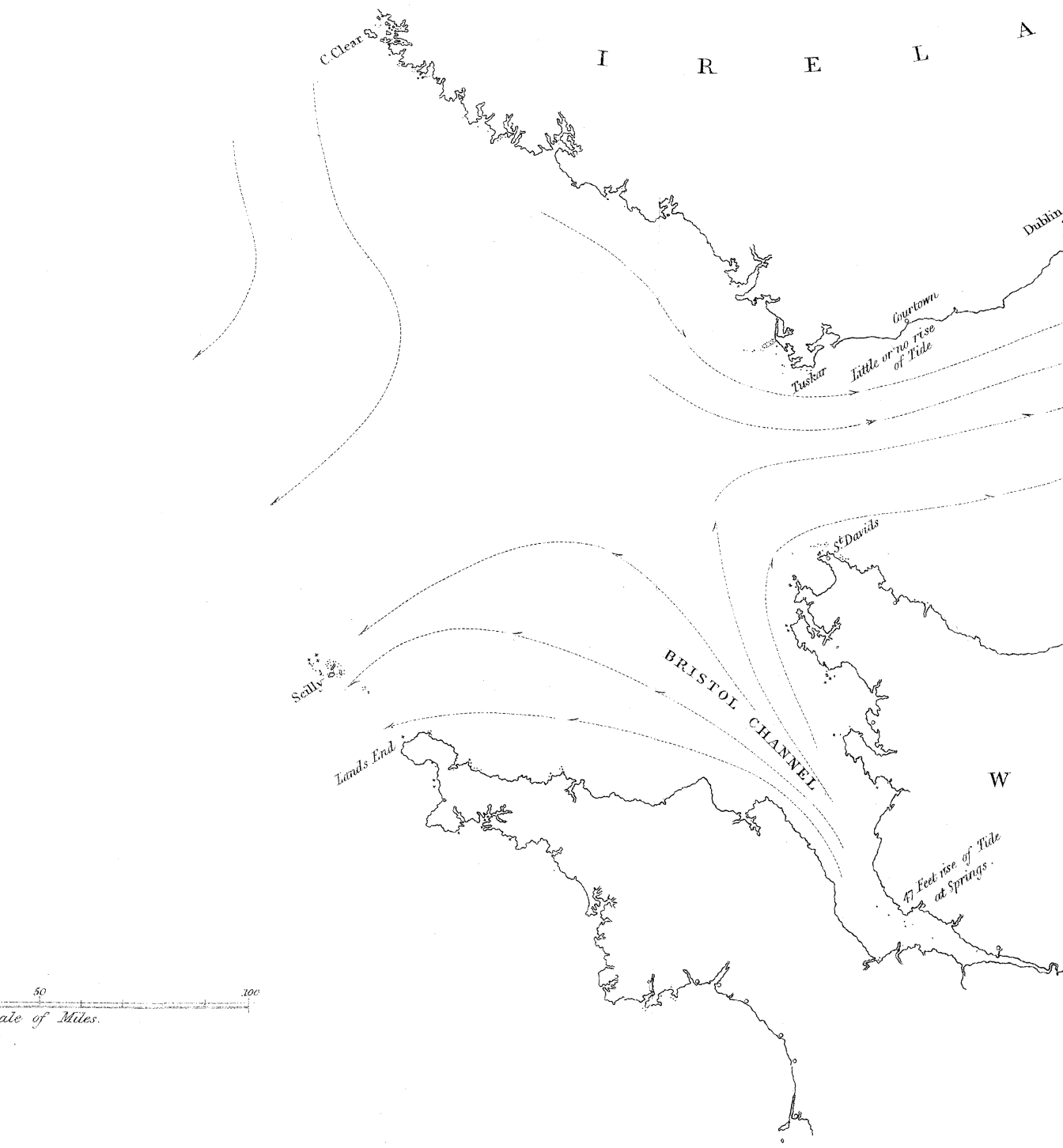
Lands End

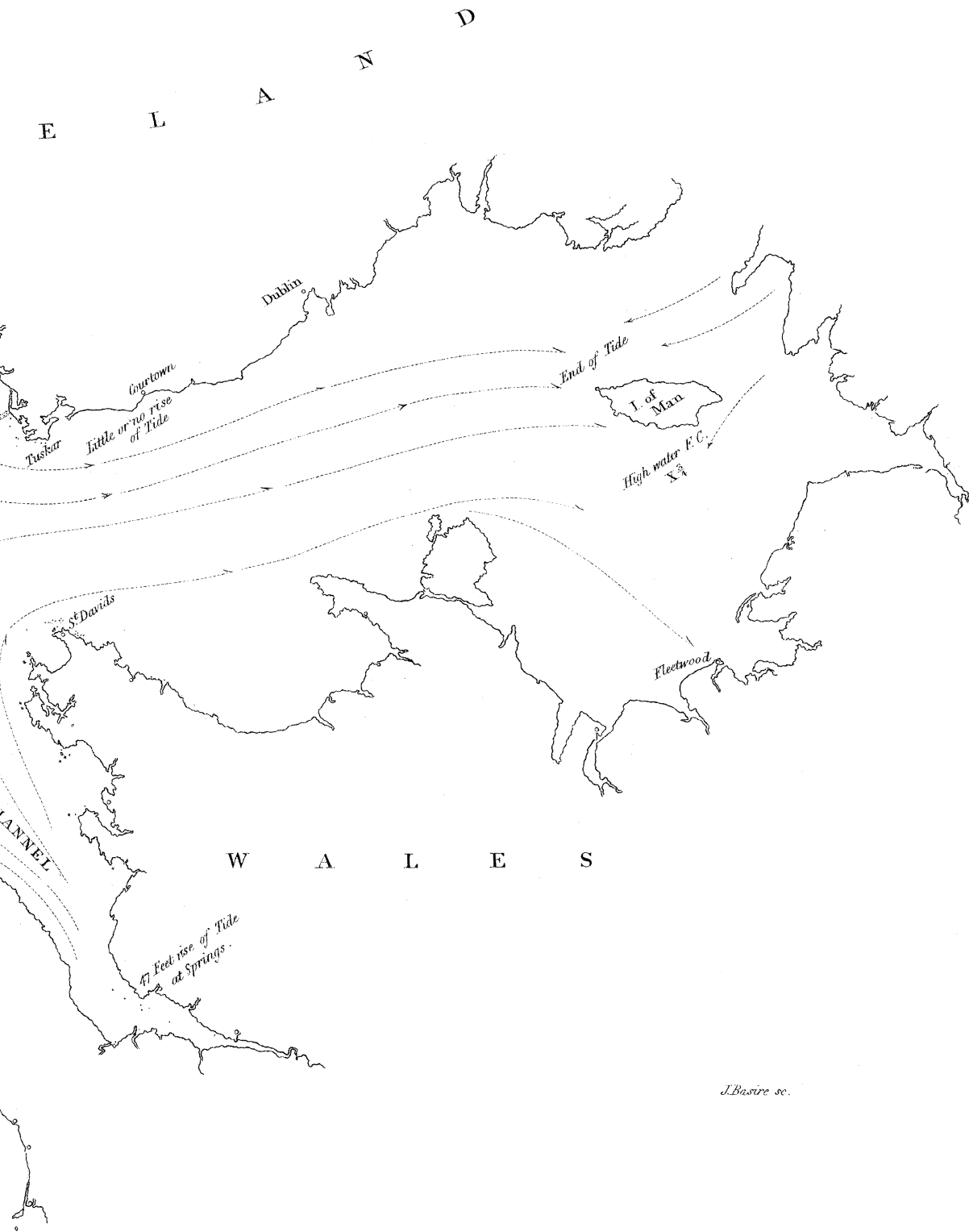
Sally

50

100

Scale of Miles.





J. Basire sc.

at a place called Courtown, a little above the contraction of the strait, and at 150 miles from Cape Clear (its entrance), there is scarcely any rise or fall of the water; and in the other channel (about Swanage), situated also a little above the contraction of the strait, and just 150 miles from the Land's End (the entrance of the channel), there is only five feet rise of the water at a spring range*. In both cases these points of small range of tide are situated on the opposite side of the channel to that of the high elevation above mentioned, and in both cases these spots are the node of the tide-wave (on either side of which the times of high and low water are reversed). And again we trace a similarity in an increased rise of the water on the south-east sides of both channels abreast of the virtual head of the tide: at Liverpool in one case, where the range amounts to thirty-two feet, and at Cayeux in the other, where it is thirty-four feet.

Comparison
continued.

It may also be shown that the progress of the tide-wave along the side of the channels opposite the node is not very dissimilar. Reckoning in both cases from the line which we have before drawn as the outer limits of the channel, we find that in the English Channel from this line to Cherbourg, opposite the small range of tide,—

| | Miles per hour. | | Miles. |
|--|-----------------|---|--------|
| The wave travels | 50 | and if complete would be in extent | 616 |
| In the Irish Channel, from a similar line to Bardsey, it travels | 52 | | 649 |
| From Cherbourg to Havre | 32 | | 397 |
| From Bardsey to Holyhead | 16 | | 193 |
| From Holyhead to end of tide | 78 | | 959 |
| Dieppe to the end of the tide | 75 | | 922 |

These numbers are given roughly, merely for the purpose of showing the general resemblance in the character and motion of the wave; and it is probable a more judicious selection of positions and numbers would give a still nearer coincidence. Besides which we are somewhat uncertain as to the establishment at our starting-point. As a comparison, however, the numbers run fairly together. In both cases the retardation of the tide-wave about mid-channel, and the great elongation of the wave towards the end of the strait are remarkable, especially in the Irish Sea.

Lastly, we may notice a singular coincidence in more respects than one, indeed, between the situation of the node placed by Professor WHEWELL† in the North Sea, and a corresponding point of small range and inversion of tide at the back of Kintire‡. The node or hinge of the tide in the North Sea is curiously enough situated as nearly as possible at *the same distance from the head of the tide off Dungeness, as the node at or near Swanage* is on the opposite side of it; and the node at Kintire communi-

* In 1834 it was 3 ft. 10 in. }
In 1835 it was 6 ft. 4 in. } 5 ft. 1 in. mean. Philosophical Transactions, 1836, Part II. p. 320.

† Philosophical Transactions, 1835, Part II. p. 298.

‡ I have recently been apprised of this by Captain ROBINSON, R.N., who is surveying the coast of Scotland, but I have not seen the observations.

cated by Captain ROBINSON, is about the same distance from the meeting of the tide in the Irish Sea as the North Sea node is from the meeting of the waters off Dungeness, and is similarly *situated with respect to the node of Courtown as the North Sea node is with regard to Swanage.*

It appears therefore that the tidal feature of these two channels corresponds in almost every particular.

Further investigation of the tidal phenomena of English Channel urged.

I cannot but consider the identity very remarkable and interesting, and especially so as concerns the relative situations of the nodes of the wave, hinging (as those in the channel appear to do) upon a *single point*, and not upon a negative line across the channel, as may have been imagined. And it seems highly desirable that a critical investigation of the phenomena of this channel should be made; not only for the purposes of science, but especially on account of the navigation of the strait, for already we may trace the cause of vessels entering the channel, being set down upon the French coast about Heaux; and who can call to mind the lamentable loss of our Indiamen on the coast about Boulogne, and not be reminded that these disasters occurred very near the point where the stream may probably be turned down upon that shore by the meeting of the tides off there?

Having now, Sir, placed before you the result of our observations upon the tides of the Irish Sea, and shown the connection which exists between the phenomena of the Irish and English Channels, and the possibility there is of forming into a system the apparently contradictory directions of the stream, at the mouths of those estuaries, which is so very desirable, I have to request that, should you, after the perusal of this letter, approve of the observations being continued round the Land's End and up the English Channel, you will solicit the Lords Commissioners of the Admiralty to furnish the means of so doing.

I have the honour to be, Sir,

Your obedient humble Servant,

F. W. BEECHEY, Captain.

To Rear-Admiral Beaufort,

&c. &c. &c.,

Hydrographer.